Circuit Theory and Electronics Fundamentals

Department of Electrical and Computer Engineering, Técnico, University of Lisbon

Example Laboratory Report

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Contents

1 Introduction

The objective of this laboratory assignment is to study a circuit containing resistors that follow Ohm's law, independent and linearly dependent voltage and current sources. With this analysis, we want to determine the potential at each of the eight nodes and the current flowing through all of the ten branches. With this purpose, we'll use both node method, that is, the usage of KVL theorem at all the nodes, considering the voltage of the nodes, and mesh method, that is, applying KCL theorem in all of the four meshes, each one with a current defined by us. (De mais??)

The circuit explained, as well as all numbered nodes and mesh currents, can be seen in Figure.

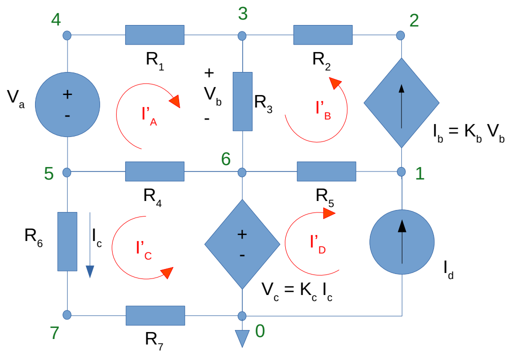

Figure 1: Voltage driven serial RC circuit.

In Section, a theoretical analysis of the circuit is presented. In Section sec:simulation, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section sec:analysis. The conclusions of this study are outlined in Section sec:conclusion. (De menos? dizer que vamos uma continuação do que dissemos no inicio na parte teórica)

2 Theoretical Analysis

In this section, the circuit shown earlier in Figure **??** is analyzed, using both node and mesh methods, as explained in section **??**. It is important to notice that node 0 corresponds to ground, meaning we assign it has having null potential.

**tabela com os valores

2.1 Node method

Using Kirchhoff Current Law (KCL) at all nodes, we end up with these equations:

$$\begin{cases} (0) V_0 = 0V \\ (1) I_d = \frac{V_1 - V_6}{R_5} + I_b \\ (2) I_b = \frac{V_2 - V_3}{R_2} \\ (3) \frac{V_2 - V_3}{R_2} = \frac{V_3 - V_4}{R_1} + \frac{V_b}{R_3} \\ (4) V_4 - V_5 = V_a \\ (5) \frac{V_6 - V_5}{R_4} = \frac{V_5 - V_7}{R_6} + \frac{V_4 - V_3}{R_1} \\ (6) V_6 = V_c \\ (7) \frac{V_5 - V_7}{R_6} = \frac{V_7}{R_7} \\ I_b = K_b V_b = K_b (V_3 - V_6) \\ V_c = K_c I_c = K_c \frac{V_5 - V_7}{R_6} \end{cases} \tag{1}$$

Where V_i represents the voltage at node i. It is important to notice that, because nodes 4 and 5 were connected to an independent voltage source, V_a, we use the source equation on equation 1.4, and for equation 1.5, we use the super-node 4-5. We used a similar though process for equation 1.6.

Substituting variables by their numeric number given in table 1, and solving this system of linear equations using *Octave*, we end up with:

Node number	Voltage (V)
V_1	11.831210311108995
V_2	7.046930516437613
V_3	7.640710157945843
V_4	7.917802934993277
V_5	2.772657156283278
V_6	7.681376099908987
V_7	0.922906185444541

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

We can get the current flowing through each branch using Ohm's law.

2.2 Mesh method

Using Kirchhoff Voltage Law (KVL) in all meshes, we can write these equations:

$$\begin{cases} (A) R_1 I'_A + R_3(I'_A + I'_B) + R_4(I'_A + I'_C) = V_a \\ (B) I'_B = I_b = K_b V_b = K_b R_3(I'_A + I'_B) \\ (C) R_4(I'_A + I'_C) + R_6 I'_C + R_7 I'_C = K_c I_c = K_c I'_C \\ (D) I'_D = -I_d \end{cases} \tag{2}$$

Because mesh B was connected to a current source, we can write the equation 2.B for this mesh. Similarly, we can write equation 2.D, for mesh D. As done in the previous subsection, we can replace the variables by their numeric number given in table 2. Solving this system of linear equations using *Octave*, we end up with:

Mesh name	Current (A)
I'_A	0.000280737730604
I'_B	-0.000294385330347
I'_C	0.000969408567879
I'_D	-0.001038309112650

Table 2: 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 Simulation Analysis

3.1 Node Analysis

Table 3 shows the node voltages obtained using the simulated operating point results for the circuit under analysis **Table** Compared to the theoretical analysis results, we notice that both are similar, having small numeric differences between them (0.2%). The most likely cause of this is due to the fact that *Octave* and *Ngspice* have different numerical precision.

Node number	Voltage (V)
v(1)	1.180671e+01
v(2)	7.061613e+00
v(3)	7.640210e+00
v(4)	7.917247e+00
v(5)	2.772101e+00
v(6)	7.679836e+00
v(7)	9.227211e-01
v(8)	2.772101e+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.

3.2 Mesh Analysis

Table 4 shows current flowing in each component using the simulated operating point results for the circuit under analysis **Table** Compared to the theoretical analysis results, we notice

Component	Current (A)
@gb[i]	-2.79317e-04
@r1[i]	-2.66368e-04
@r2[i]	-2.79317e-04
@r3[i]	-1.29490e-05
@r4[i]	-1.18616e-03
@r5[i]	-1.31763e-03
@r6[i]	9.197892e-04
@r7[i]	9.197892e-04
hc-branch	1.185199e-04
va-branch	-2.66368e-04

Table 4: Operating point. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

that, like in subsection 3.1, both are similar, having differences 5%. We think the causes are the same described earlier, with the adition that *Ngspice* uses node analysis in it's simulations, which causes an increased deviation of these values, compared to those in subsection 3.1.

4 Conclusion

In this laboratory assignment the objective of analysing an RC circuit has been achieved. Static, time and frequency analyses have been performed both theoretically using the Octave maths tool and by circuit simulation using the Ngspice tool. The simulation results matched the theoretical results precisely. The reason for this perfect match is the fact that this is a straightforward circuit containing only linear components, so the theoretical and simulation models cannot differ. For more complex components, the theoretical and simulation models could differ but this is not the case in this work.

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