Circuit Theory and Electronics Fundamentals

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Mestrado em Engenharia Aeroespacial

Laboratory 1 Report

Group 7

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1 Introduction

The objective of this laboratory assignment is to study a circuit containing both dependent (I_b, V_c) and independent (I_d, V_a) current and voltage sources, connected to resistors (R_1 to R_7). The circuit and its organization can be seen in Figure 1.

In Section 2, a theoretical analysis of the circuit is presented. In Section 3, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section 2. The conclusions of this study are outlined in Section 4.

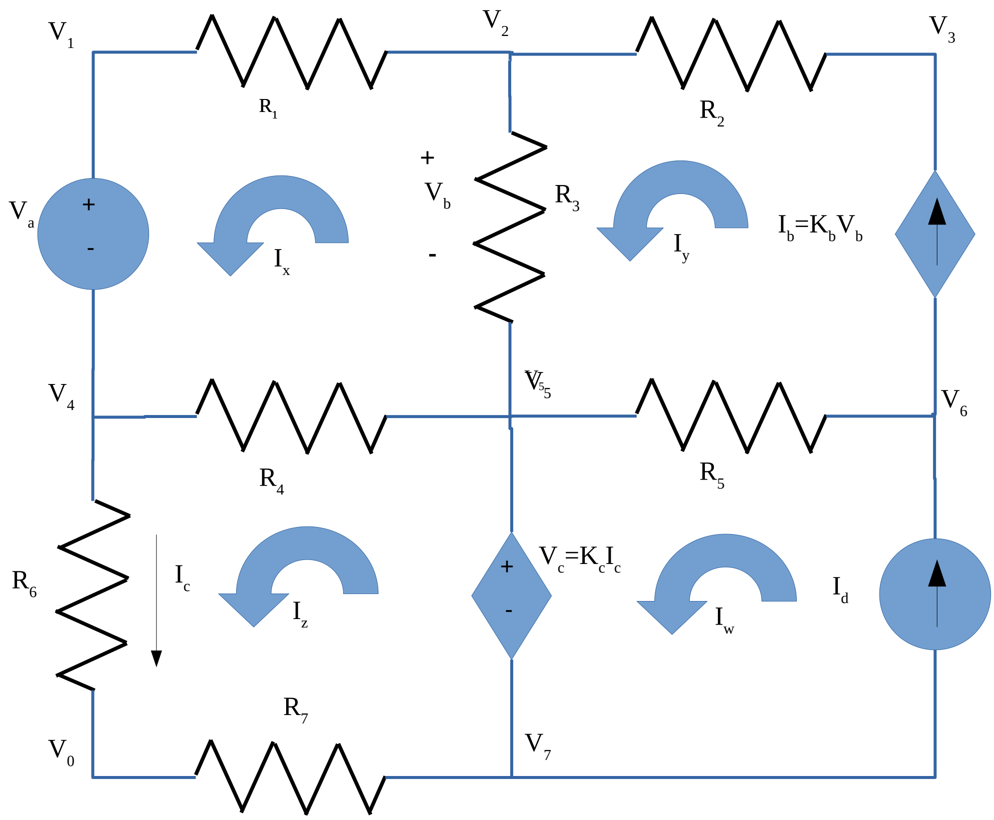

Figure 1: Circuit topography

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, through the methods of Mesh Analysis and Node Analysis.

2.1 Mesh Analysis

In this subsection of the report we are going to analyse the circuit through the Mesh method in order to obtain the four currents in the four meshes of the circuit: I_x, I_y, I_z, I_w. For that, we apply Kirchhoff's Voltage Law (KVL) in each of the meshes, obtaining the following equations:

Name	Value [A]
@I_x	0.000261
@I_y	0.000273
@I_z	-0.000942
@I_w	0.001013

Table 1: Currents obtained in the theoretical analysis in Octave

2.2 Node Analysis

Here, we made use of Node Analysis to determine the voltages in each of the nodes. For that, we assigned the nodes an identification as you see in Figure 1.

We can then solve for the nodes, by calculating the potencial diferences between each node. That leaves us with 7 equations, one for each node excluding the ground node, denoted as Node 0. Solving the equations, we obtain the following matrix:

Name	Value [V]
V_1	7.048489
V_2	6.777542
V_3	6.219677
V_4	1.944932
V_5	6.815522
V_6	10.826189
V_7	-0.952500
V_8	-0.952500

Table 2: Voltages obtained in the theoretical analysis in Octave

3 Simulation Analysis

Since the voltage and current sources have constant values, we only need to use the Operating Point analysis to fully study the circuit.

3.1 Operating Point Analysis

While using Ngspice we encountered some problems with the use of current-controlled voltage sources. To overcome them, we introduced a dummy 0V voltage source between the resistors 6 and 7. The voltage source V_c depends on the current I_c, which is the current on R_6. However, since Ngspice could not take the current in R_6, we introduced the null voltage source, since the current there will be I_c, which is the current that V_c depends on.

Table 3 shows the simulated operating point results for the circuit under analysis. Compared to the theoretical analysis results, one notices the following differences: describe and explain the differences.

First, we must take into consideration that the currents flowing through R1, R2, R3 and R4 are, respectively, equal to I_x, I_y, I_z and I_w. Comparing the tables 1 and 2 with table 3, we see that the difference between the different voltages and currents is minimal. Different digits beggin to appear only on the fourth decimal case and these disparities can be attributed to distinct methods of calculation and floating point.

On the other hand, by analysing table 3, we note that in each resistor the current and voltage values have the same sign, as it should be since the power of a resistor must be positive.

Having verified that the theoretical results and the simulation results are very much approximate, with minor acceptable differences, we say that the methods used to study the circuit are accurate.

Name	Value [A or V]
@gib[i]	-2.60149e-04
@id[current]	1.012649e-03
@rr1[i]	-2.48209e-04
@rr2[i]	-2.60149e-04
@rr3[i]	-1.19393e-05
@rr4[i]	-1.19218e-03
@rr5[i]	-1.27280e-03
@rr6[i]	9.439751e-04
@rr7[i]	9.439751e-04
v(1)	7.053027e+00
v(2)	6.795298e+00
v(3)	6.264646e+00
v(4)	1.949470e+00
v(5)	6.831425e+00
v(6)	1.080049e+01
v(7)	-9.54723e-01
v(9)	0.000000e+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.

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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