Circuit Theory and Electronics Fundamentals

Integrated Master's in Aerospace Engineering, Técnico, University of Lisbon

Laboratory 1 Report

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1 Introduction

The objective of this laboratory assignment is to study a circuit containing an independent voltage source V_A, an independent current source I_D, seven resistors, a linearly dependent current source I_B and a linearly dependent voltage source V_C. The circuit can be seen if Figure 1. The study of the circuit is done using both the mesh and the nodal analysis methods.

In Section 2, a theoretical analysis of the circuit using Octave is presented. In Section 5, the circuit is analysed by simulation with NGSpice software and the results are compared to the theoretical results obtained in Section 2. Conclusions of this study can be found in Section 6.

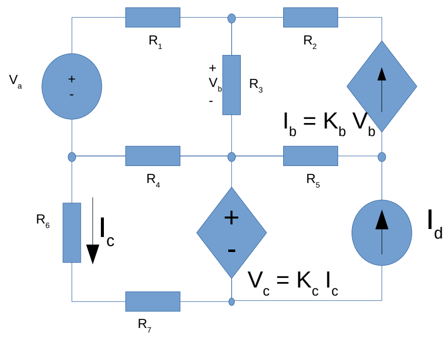

Figure 1: Circuit in study.

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, in terms of each branch's current and voltage.

3 Nodal Analysis

This method is based on Kirchhoff's Current Law (KCL), and firstly consists in deriving equations for the current flow in nodes not connected to voltage sources, followed by writing aditional equations in nodes related to voltage sources. The node identification can be seen on Figure 1. Moreover, the equations relative to nodes 0, 2, 5 and 0 , respectively, are

$$(V_0 - V_4)G_4 + (V_0 - V_6)G_6 + (V_1 - V_2)G_1 = 0 \tag{1}$$

$$(V_2 - V_1)G_1 + (V_2 - V_4)G_3 + (V_2 - V_3)G_2 = 0 \tag{2}$$

$$(V_5 - V_4)G_5 + I_b - I_d = 0, I_b = K_b(V_2 - V_4) \tag{3}$$

$$(V_6 - V_7)G_7 + (V_0 - V_4)G_4 + (V_1 - V_2)G_1 = 0 \tag{4}$$

The aditional equations for the method are

$$V_0 = 0 \tag{5}$$

$$V_1 = V_a \tag{6}$$

$$V_4 - V_7 = K_c(V_0 - V_6)G_6 \tag{7}$$

$$I_b = (V_3 - V_2)G_2, I_b = K_b(V_2 - V_4) \tag{8}$$

4 Mesh Analysis

This method is based on Kirchoff's Voltage Law (KVL), and consists on analysing the circuit's meshes after creating arbitrary currents with arbitrary flows for each mesh in the circuit. The top left mesh was named mesh A with clockwhise current flow I_a; the top right mesh was named mesh B with counterclockwhise current flow I_b; the bottom left mesh was named mesh C with counterclockwhise current flow I_c; the bottom right mesh was named mesh D with counterclockwhise current flow I_d. Furthermore, the equations associated with these meshes and currents are

$$R_1 I_A + R_3(I_A + I_B) + R_4(I_A + I_C) - V_a = 0 \tag{9}$$

$$R_6 I_C + R_7 I_C - K_c I_C + R_4(I_A + I_C) = 0 \tag{10}$$

$$I_D = I_d \tag{11}$$

$$I_B = K_b R_3(I_A + I_B) \tag{12}$$

5 Simulation Analysis

5.1 Operating Point Analysis

Table 1 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.

Name	**Value [A or V]**
@gb[i]	-2.65898e-04
@id[current]	1.028722e-03
@r1[i]	2.536488e-04
@r2[i]	2.658976e-04
@r3[i]	-1.22488e-05
@r4[i]	1.205310e-03
@r5[i]	-1.29462e-03
@r6[i]	9.516615e-04
@r7[i]	9.516615e-04
v(1)	5.054819e+00
v(2)	4.793705e+00
v(3)	4.258198e+00
v(4)	4.831047e+00
v(5)	8.907510e+00
v(6)	-1.93423e+00
v(7)	-2.90523e+00
v(8)	-1.93423e+00

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.

6 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.