TÉCNICO LISBOA

Circuit Theory and Electronics Fundamentals

Lab 1 - Circuit Analysis Methods

Aerospace Engineering

Laboratory Report

March 24, 2021

Eva Claro, 95785

Miguel Isidoro, 95834

Pedro Braz, 95837

Contents

1 Introduction

This report is being made for the subject of Circuit Theory and Electronics Fundamentals and is related to the 1^{st} laboratory.

The objective of this laboratory assignment is to study a circuit containing 7 resistors, 1 voltage source, 1 current source, 1 current controlled voltage source and 1 voltage controlled current source.

The display of this circuit can be seen in Figure 1.

In Section 2 we will analise theorically the circuit and present the results obtained by Octave.

Secondly, in Section 3 we will simulate the circuit using ngspice, present the results obtained and compare them with the ones gathered from Section 2.

The conclusions of this study are outlined in Section 4.

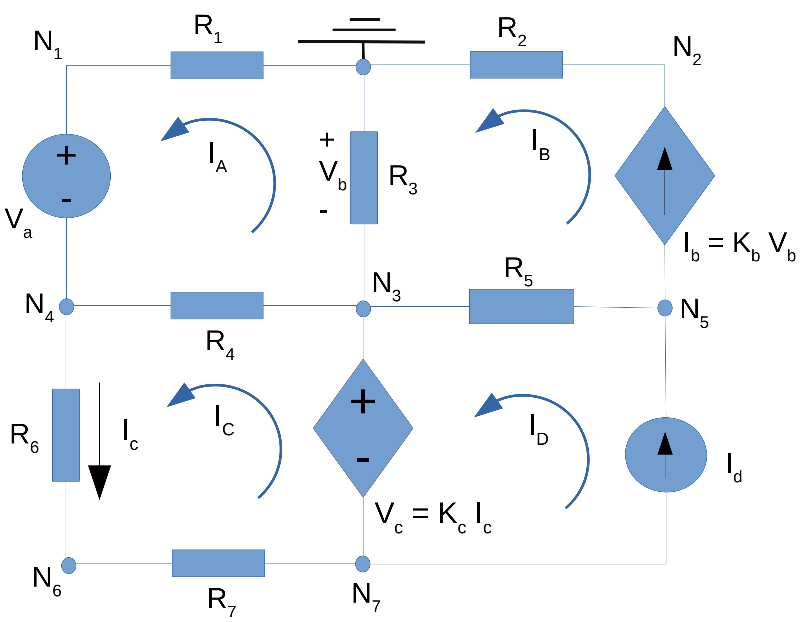

Figure 1: Circuit with the nodes

Where:

$$R_1 = 1.03431507833$$
$$R_2 = 2.02853090731$$

$$R3 = 3.1462050633$$
$$R_4 = 4.03438547455$$
$$R_5 = 3.12170042214$$
$$R_6 = 2.07116379646$$
$$R_7 = 1.01597753093$$
$$V_a = 5.156959346$$
$$I_d = 1.01455683569$$
$$K_b = 7.1497941196$$
$$K_c = 8.12593642585$$

Units for the values: $V, mA, k\Omega$ and mS

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, in terms of it's node voltages and mesh currents.

2.1 Mesh Analysis Method

ESCREVER AQUI ALGUMA COISA

Starting by number the nodes arbitrarily, assigning current names and directions to all branches also arbitrarily and defining one node as ground (GND) a system of equations obtained applying the Kirchhoff Current Law (KCL)to each mesh can be written as

$$\begin{bmatrix} R_1 + R_3 + R_4 & -R_3 & -R_4 \\ -R_4 & 0 & R_4 + R_6 + R_7 - K_C \\ -K_B R_3 & K_B R_3 - 1 & 0 \end{bmatrix} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} = \begin{bmatrix} -V_A \\ 0 \\ 0 \end{bmatrix} \quad (1)$$

It was used 3 equations (4 meshes - 1 = 3 linearly independent equations)

It's important to notice that D loop is independent from the restant ones so we don't need to determine the current I_D as it is given on the inicial data.

After solving the system with Octave tools we get the Table 1 results.

Name	Value [A or V]
IA	-2.4409e-04
IB	-2.5545e-04
IC	9.8044e-04
ID	1.0146e-03
Ib	-2.5545e-04
Ic	9.8044e-04
Vb	-3.5728e-02
Vc	7.9670e+00

Table 1: Results obtained by mesh analysis method with octave tool

2.2 Nodal Analysis Method

The Nodal Analysis Method is another general procedure analysing circuits using node voltages as the circuit variables.

To find the nodal voltages we chose 7 equations (8 nodes - 1 = 7 linearly independent equations) that comprise:

- KCL in nodes not connected to voltage sources;
- Additional equations for nodes related by voltage sources.

The system of equations tha will be solved is:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -G_1-G_2-G_3 & G_1 & G_2 & G_3 & 0 & 0 & 0 & 0 \\ K_b+G_2 & 0 & -G_2 & -K_b & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 \\ -K_b & 0 & 0 & K_b+G_5 & 0 & -G_5 & 0 & 0 \\ 0 & 0 & 0 & 0 & G_6 & 0 & -G_6-G_7 & G_7 \\ 0 & 0 & 0 & 1 & -K_cG_6 & 0 & K_cG_6 & -1 \\ G_3 & 0 & 0 & -G_4-G_3-G_5 & G_4 & G_5 & G_7 & -G_7 \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \\ V_6 \\ V_7 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ V_a \\ -I_d \\ 0 \\ 0 \\ I_d \end{bmatrix} \tag{2}$$

After solving the system with Octave tools we get the Table 2 results.

Name	Value [A or V]
V0	0.0000e+00
V1	2.5247e-01
V2	-5.1818e-01
V3	3.5728e-02
V4	-4.9045e+00
V5	4.0003e+00
V6	-6.9351e+00
V7	-7.9312e+00
Vb	-3.5728e-02
Ib	-2.5545e-04
Vc	7.9670e+00
Ic	9.8044e-04

Table 2: Results obtained by nodal analysis method with octave tool

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

3 Simulation Analysis

3.1 Operating Point Analysis

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.

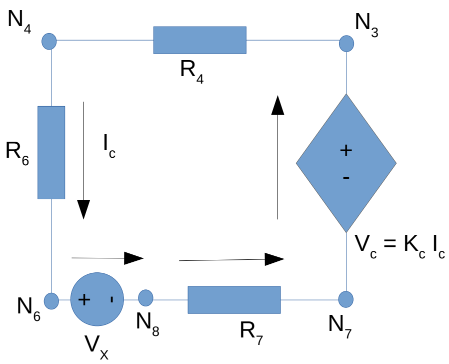

Figure 2: C Mesh with an adicional voltage source

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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.A Eva é linda e apredneu a trabalhar com isto.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Name	**Value [A or V]**
@vx[i]	9.804367e-04
@hc[i]	3.412015e-05
@va[i]	-2.44092e-04
@gb[i]	-2.55448e-04
@id[current]	1.014557e-03
@r1[i]	-2.44092e-04
@r2[i]	-2.55448e-04
@r3[i]	-1.13559e-05
@r4[i]	-1.22453e-03
@r5[i]	-1.27000e-03
@r6[i]	9.804367e-04
@r7[i]	9.804367e-04
n1	2.524677e-01
n2	-5.18183e-01
n3	3.572797e-02
n4	-4.90449e+00
n5	4.000301e+00
n6	-6.93514e+00
n7	-7.93124e+00
n8	-6.93514e+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.