Circuits Theory and Eletronic Fundamentals

Aerospace Engineering Master's Degree

Laboratory 1 Report

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1 Introduction

The objective of this laboratory assignment is to study a circuit containing a voltage source V_a, a current source I_d, a linear voltage dependent current source I_b, a linear current dependent voltage source V_c and multiple resistors $R1, ..., R7$. The circuit 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.

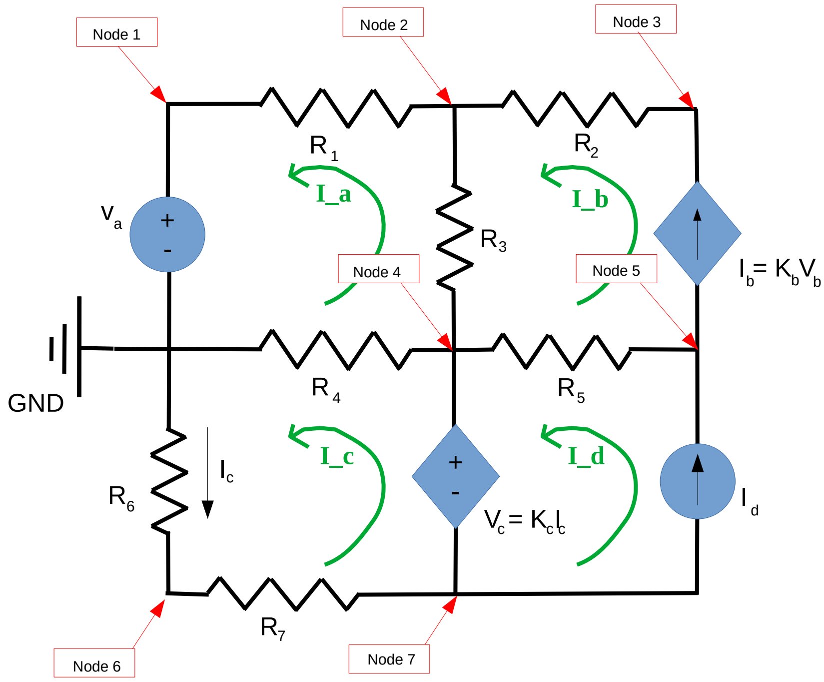

Figure 1: Voltage driven serial RC circuit.

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, in terms of its response when submited to a voltage in voltage source V_a and a current in the current source I_d, using Octave.

The circuit consists of four loops, where on the top left loop (loop 1) flows a current I_a, on the top right (loop 2) flows a current I_b, on the bottom left (loop 3) a current I_c and on bottom right loop (loop 4) a current I_d, all of them assigned to be flowing counterclockwise for the mesh analysis. The voltage and current sources, v_a and I_d, receive countinuous inputs and in order to analyse the circuit we have to measure the voltage in each node and the current flowing in each loop. For this purpose we will apply both the Kirchhoff Voltage Law (KVL) and Kirchhoff Current Law (KCL).

Starting the analysis using KVL, we obtain four equations correspondent to each loop:

$$R_1 I_a + R_3(I_a - I_b) + R_4(I_a - I_c) = -v_a; \tag{1}$$

$$K_b R_3(-I_a + I_b) - I_b = 0; \tag{2}$$

$$R_4(-I_a + I_c) + R_6 I_c + R_7 I_c - K_c I_c = 0; \tag{3}$$

$$I_d = I_d. \tag{4}$$

Using Octave, we can solve this system of equations easily using matrix operations obtaining the following solution for the currents:

Name	Value [A or V]
Ia	-0.000199
Ib	-0.000209
Ic	0.001001
Id	0.001041
Vb	-0.029341
Ic	0.001001
Ib	-0.000209
Vc	8.038843

Table 1: Results using mesh method

As for the analysis using KCL, since we have 8 different nodes we must have 8 different equations in order to have a solvable system of equations, therefore we obtain the following set of equations:

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

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

$$\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_3}{R_2} + \frac{V_2 - V_4}{R_4} = 0; \tag{7}$$

$$\frac{V_3 - V_2}{R_2} - K_b(V_2 - V_4) = 0; \tag{8}$$

$$K_b(V_2 - V_4) + \frac{V_5 - V_4}{R_5} = I_d; \tag{9}$$

$$\frac{V_6}{R_6} + \frac{V_6 - V_7}{R_7} = 0; \tag{10}$$

$$V_4 - K_c\frac{V_6}{R_6} - V_7 = 0; \tag{11}$$

$$\frac{V_4}{R_4} + \frac{V_4 - V_2}{R_3} + \frac{V_4 - V_5}{R_5} + \frac{V_7 - V_6}{R_7} = -I_d, \tag{12}$$

being **Equation 5** referent to node 0,**Equation 6** to node 1, **Equation 7** to node 2, **Equation 8** to node 3, **Equation 9** to node 5, **Equation 10** to node 6, **Equation 11** to the linear current dependent voltage source and **Equation 12** to the sum of both nodes 4 and 7.

Using Octave, we can solve this system of equations easily using matrix operations obtaining the following solution for the voltages:

As expected from theory, both methods present the same results as can be seen in tables 1 and 2.

Name	Value [A or V]
V0	0.000000
V1	5.195199
V2	4.989875
V3	4.556619
V4	5.019215
V5	8.853743
V6	-2.012617
V7	-3.019628
Ic	0.001001
Ib	-0.000209

Table 2: Results using nodes method

3 Simulation Analysis

Name	Value [A or V]
@gb[i]	-2.08664e-04
@id[current]	1.041397e-03
@r1[i]	1.992363e-04
@r2[i]	2.086637e-04
@r3[i]	-9.42740e-06
@r4[i]	1.200363e-03
@r5[i]	-1.25006e-03
@r6[i]	1.001127e-03
@r7[i]	1.001127e-03
v(1)	5.195199e+00
v(2)	4.989875e+00
v(3)	4.556619e+00
v(4)	5.019215e+00
v(5)	8.853743e+00
v(6)	-2.01262e+00
v(7)	-3.01963e+00
v(8)	-2.01262e+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.

Table 3 shows the simulated operating point results for the circuit under analysis. Compared to the theoretical analysis results, the simulation analysis results are the same due to all components having a linear behaviour.

4 Conclusion

In this laboratory assignment the objective of analysing the mentioned circuit has been achieved. Voltages and Current static analyses have been performed both theoretically using the Octave tools and by circuit simulation using the Ngspice tools. The simulation results matched the theoretical results precisely and both theoretical analyses produce consistent results. 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.