TÉCNICO LISBOA

Lab 01 Report

Circuit Theory and Eletronic's Fundamentals

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1 Introduction

The objective of this laboratory assignment is to study a stationary circuit containing two voltage sources V_a, independent, and V_c, dependent, two current sources, I_d, independent and I_b, dependent, and resistors, as shown in Figure 1.

In Section 2, a theoretical analysis of the circuit is presented, based on mesh and nodal methods. In Section 3, the circuit is analysed by simulation, and the results are compared to the one presented before in Section 2. The conclusions of this study are outlined in Section 4.

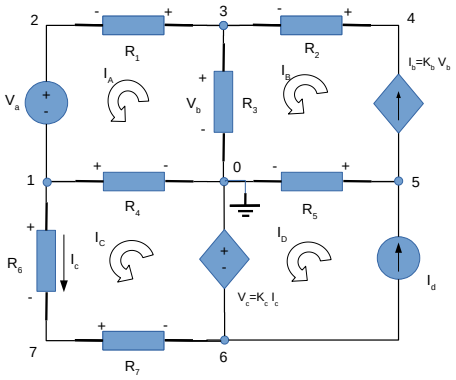

Figure 1: Studied Circuit.

2 Theoretical Analysis

2.1 Nodal analysis

In this section, we begin by applying Kirchoff's current law (along with Ohm's law) to the nodes, considering the currents specified earlier. The following equations were obtained,

$$\frac{V_3}{R_3} + \frac{V_3 - V_2}{R_1} = \frac{V_4 - V_3}{R_2} \tag{1}$$

$$\frac{V_4 - V_3}{R_2} = K_b V_3 \tag{2}$$

$$I_d = \frac{V_5}{R_5} + K_b V_3 \tag{3}$$

$$\frac{V_1 - V_7}{R_6} = \frac{V_7 - V_6}{R_7} \tag{4}$$

$$\frac{V_3 - V_2}{R_1} = \frac{V_1}{R_4} + \frac{V_1 - V_7}{R_6} \tag{5}$$

$$V_2 - V_1 = V_A \tag{6}$$

$$V_6 = -K_c \frac{V_1 - V_7}{R_6} \tag{7}$$

Or, in matrix form

$$\begin{pmatrix} 0 & \frac{-1}{R_1} & \frac{1}{R_3} + \frac{1}{R_1} + \frac{1}{R_2} & \frac{-1}{R_2} & 0 & 0 & 0 \\ 0 & 0 & \frac{-1}{R_2} - K_b & \frac{1}{R_2} & 0 & 0 & 0 \\ 0 & 0 & K_b & 0 & \frac{1}{R_5} & 0 & 0 \\ \frac{1}{R_6} & 0 & 0 & 0 & 0 & \frac{1}{R_7} & \frac{-1}{R_6} - \frac{1}{R_7} \\ \frac{1}{R_4} + \frac{1}{R_6} & \frac{1}{R1} & \frac{-1}{R1} & 0 & 0 & 0 & \frac{-1}{R_6} \\ -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ \frac{K_c}{R_6} & 0 & 0 & 0 & 0 & 1 & -\frac{K_c}{R_6} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \\ V_6 \\ V_7 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ I_d \\ 0 \\ 0 \\ V_A \\ 0 \end{pmatrix} \tag{8}$$

Where the last two equations are voltage equations for the voltage sources.
Solving this equation on Octave, we get:

$$V = \begin{bmatrix} -4.8747 \\ 0.22615 \\ -0.038986 \\ -0.6202 \\ 4.007 \\ -7.8012 \\ -6.8333 \end{bmatrix}$$

where V is the voltage with the node voltages in Volts.

2.2 Mesh Analysis

$$R_1 I_A - R_3(I_B - I_A) + R_4(I_A - I_C) + V_A = 0 \tag{9}$$
$$-R_4(I_A - I_C) + R_6 I_C + R_7 I_C - K_C I_C = 0 \tag{10}$$
$$I_B = K_b R_3 (I_A + I_B) \tag{11}$$

Again, in matrix form and subsequently solving in octave we get,

$$\begin{pmatrix} R_1 + R_3 + R_4 & -R_3 & -R_4 \\ -R_4 & 0 & R_4 + R_6 + R_7 - K_C \\ -K_b R_3 & K_b R_3 - 1 & 0 \end{pmatrix} \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix} = \begin{pmatrix} -V_A \\ 0 \\ 0 \end{pmatrix} \tag{12}$$

$$I = \begin{bmatrix} -0.264261 \\ -0.277043 \\ 0.944184 \end{bmatrix}$$

The mesh analysis produced three currents[1]. The remainder three currents can be calculated by summing $I_A\, I_B\, I_C$ accordingly to 11 .

$$I_{R_3} = I_B - I_A \tag{13}$$
$$I_{R_4} = I_A - I_C \tag{14}$$
$$I_{R_5} = I_D - I_B \tag{15}$$

hence,

$$I_{R3} = -0.0127815mA$$
$$I_{R4} = -1.208445mA$$
$$I_{R5} = 1.290270mA$$

3 Simulation Analysis

We ran a simulation of the circuit using *Ngspice* thus obtaining the following results,

Table 1 presents the voltage mesured at four nodes, while there are only seven non-0V in the circuit. This is a result of *Ngspice* requiring a voltage source in order to mesure the

[1] It should be noted that these values are in miliAmperes.

Name	Value [A or V]
@r1[i]	-2.64261e-04
@r2[i]	-2.77043e-04
@r3[i]	-1.27815e-05
@r4[i]	-1.20845e-03
@r5[i]	1.290270e-03
@r6[i]	9.441840e-04
@r7[i]	9.441840e-04
v(1)	-4.87466e+00
v(2)	2.261481e-01
v(3)	-3.89856e-02
v(4)	-6.20197e-01
v(5)	4.006987e+00
v(6)	-7.80120e+00
v(7)	-6.83331e+00
v(8)	-6.83331e+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.

voltage for a voltage dependent source, as I_b. Naturally, this extra voltage source was set to zero volts, hence acting only as shunt. As one can see the voltage between v(7) and v(8) are the same, this was where the extra source was connected. As one can see, the voltage at the nodes matches the nodal analysis, and the currents match the mesh analysis, (given the approximations done by *Ngspice* of it's output) as expected.

4 Conclusion

In this laboratory assignment the objective of analysing a stationary circuit consisting of resistors, dependent and independent sources was achieved. Nodal and mesh analysis have been performed theoretically using the Octave maths tool and circuit simulation was performed using the Ngspice tool. The simulation results matched the theoretical results. The reason for this 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.