Circuit Theory and Electronics Fundamentals

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Laboratory Report 1

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Contents

1 Introduction

The objective of this laboratory assignment is to do analysis on a circuit using the mesh and the nodal method as well as running a simulation using NgSpice with the objective of detecting small diferences between the different approcahes and understand why said differences happen. 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.

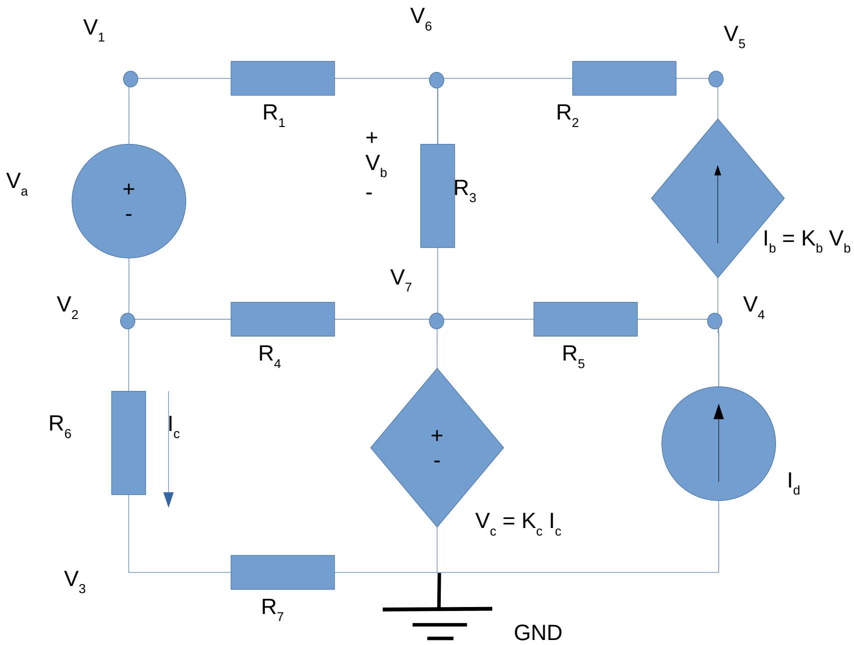

Figure 1: Circuit with an independent current and voltage source (V_a and I_d respectively) and linear dependent sources (V_c-linear current controlled voltage source and I_b-linear voltage controlled current source

The values given for this report can be found in table 1.

Name	Values
R1	1.01949191994 Kohms
R2	2.05054429461 Kohms
R3	3.09286027724 Kohms
R4	4.12838973576 Kohms
R5	3.06635427647 Kohms
R6	2.01254230153 Kohms
R7	1.00502981701 Kohms
Va	5.24204797361 V
Id	1.01905568201 mA
Kb	7.23185131759 mS
Kc	8.12820254987 Kohms

Table 1: Values received by the Python program.

2 Theoretical Analysis

2.1 Mesh Analysis

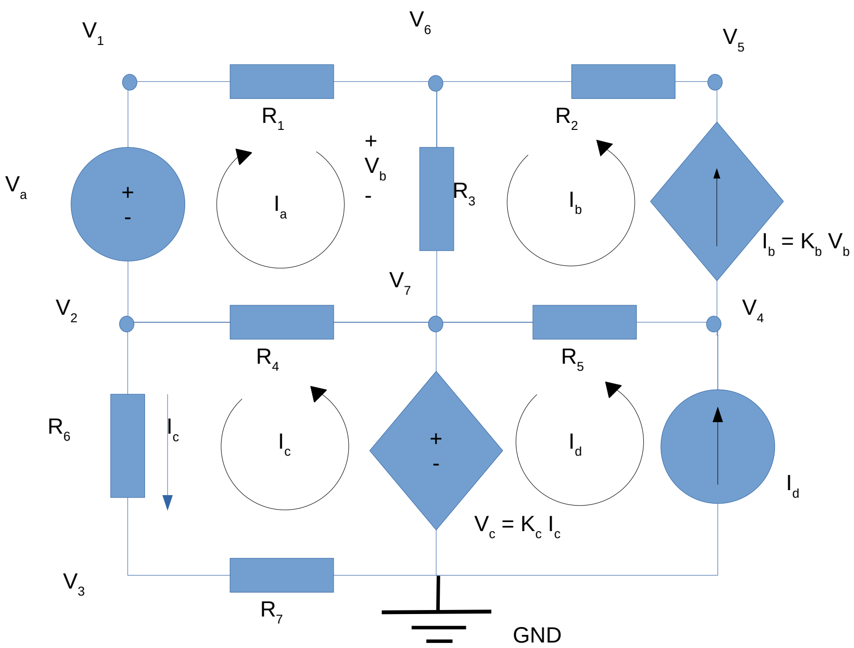

Figure 2: Representation of mesh currents in the circuit.

Figure 2 shows the mesh currents considered for the circuit analysis, with the current I_a flowing clockwise and the rest of the currents (I_b, I_c and I_d) flowing counter-clockwise. In the meshes containing I_b and I_d, the currents were considered to be the same as the current sources in said meshes.

From this circuit, there can then be extracted 3 equations to figure out the value of the components necessary for the circuit analysis.

The first one, Equation 1 , was obtained by using Ohm's Law, assuming it is known the value of the voltage and the resistence in resistor 3 and that the current flowing through it is (I_a + I_b).

$$I_b = K_b(I_a + I_b)R_3, \tag{1}$$

Equation 2 was figured out by analysing the top left mesh, using Kirchoff's Voltage Law and Ohm's Law for the resistors. Since the current I_a is flowing clockwise, the voltage in V_a is negative and the currents in resistors 3 and 4 are, correspondingly, (I_a + I_b) and (I_a + I_c), as these pairs of currents are flowing the same way in said resistors.

$$-V_a + I_aR_1 + (I_a + I_b)R_3 + (I_a + I_c)R_4 = 0, \tag{2}$$

Finally, from the bottom left mesh, there is Equation 3, in which was also used Kirchoff's Voltage Law and Ohm's Law. The voltage in V_ac is negative due to the current flow.

$$-K_cI_c + I_cR_6 + I_cR_7 + (I_a + I_c)R_4 = 0, \tag{3}$$

By developing these 3 equations, the matrix below (4) is achieved as to simplify the calculations. This matrix was solved in Octave, getting the values of the currents I_a, I_b and I_c. It was not necessary to solve for the value of the current in the bottom right mesh since it is already known (equivalent to I_d).

$$\begin{bmatrix} -K_bR_3 & 1-K_bR_3 & 0 \\ R_1+R_3+R_4 & R_3 & R_4 \\ R_4 & 0 & R_6+R_7-K_c+R_4 \end{bmatrix} \times \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 0 \\ V_a \\ 0 \end{bmatrix} \quad (4)$$

The values of I_a, I_b and I_c are then, correspondingly, (2.5852e-4)V, (-2.7062e-4)V and (1.0865e-3)V. With these currents, it is possible to discover the values of the voltages in each node, using the equations 5 through 11 down below and knowing that I_b = K_bV_b and V_c=K_cI_c.

$$V_7 = V_c, \quad (5)$$

$$V_6 = V_7 + V_b, \quad (6)$$

$$V_5 = V_6 + R_2I_b, \quad (7)$$

$$V_4 = V_7 + R_5I_d, \quad (8)$$

$$V_3 = V_0 + R_7I_c, \quad (9)$$

$$V_2 = V_3 + R_6I_c, \quad (10)$$

$$V_1 = V_2 + V_a, \quad (11)$$

The following table(2) shows the node voltages discored by replacing the variables with the known values. Notice that the values are not equal to the ones obtained by the simulation analysis or the node analysis. This is due to the fact that the mesh analysis is not as exact as the other methods; however, the results are similar enough to be relevant to this experiment.

Node	Voltage[V]
V_1	8.5206e00
V_2	3.2785e00
V_3	1.0920e00
V_4	1.1956e01
V_5	7.4396e00
V_6	7.9946e00
V_7	8.8313e00

Table 2: Voltage values using the mesh analysis.

2.2 Nodal Analysis

3 Simulation Analysis

Table 3 shows the simulated operating point results for the circuit under analysis given the values found in Table 1.

Name	**Value [A or V]**
@gib[i]	-2.45467e-04
@id[current]	1.019056e-03
@r1[i]	2.344922e-04
@r2[i]	-2.45467e-04
@r3[i]	1.097445e-05
@r4[i]	1.220071e-03
@r5[i]	-1.26452e-03
@r6[i]	-9.85579e-04
@r7[i]	-9.85579e-04
v1	8.216102e+00
v2	2.974054e+00
v3	9.905358e-01
v4	1.188846e+01
v5	7.473699e+00
v6	7.977039e+00
v7	8.010982e+00
v8	2.974054e+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. (the g in ”gib” refers to the NgSpice notation of a voltage controlled current source)

We can get all the missing values given the equations showed in section 2.

$$V_c = V_7 \tag{12}$$

$$V_b = \frac{I_b}{K_b} \tag{13}$$

4 Conclusion

TO BE DONE