Circuit Theory and Electronics Fundamentals

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Laboratory 1 Report

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Contents

1 Introduction

The objective of this laboratory assignment is to study a circuit containing several resistors R_n, two current sources, I_d and I_b, with one of them beeing dependant, and two tension sources, V_a and V_c, with the latter beeing dependant. The circuit can be seen if 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.

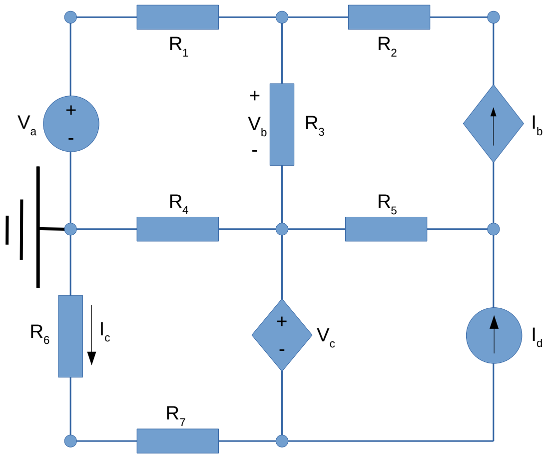

Figure 1: t1 circuit.

2 Theoretical Analysis

We are now going to make a theoretical analysis of the given circuit shown in Figure 1 based on the Mesh Method (KVL) and the Nodes MEthod (KCL), to then take some conclusions.

2.1 Mesh Method

To use the mesh method we start from the principle that the total voltage in a closed loop equals to zero. That means that any closed part of the circuit should have equal voltage providence in the sources of tension to the voltage drop in other components. In a circuit only with tension and current sources as well as resistors, every Mesh will provide us with a linear equation. The number of independ linear equations will equal the number of elementary, as shown in Figure 2, meshes in the circuit so this are the ones we are going to analyse. For facilitation purposes we assigned a current direction (clockwise) to every elementary Mesh.

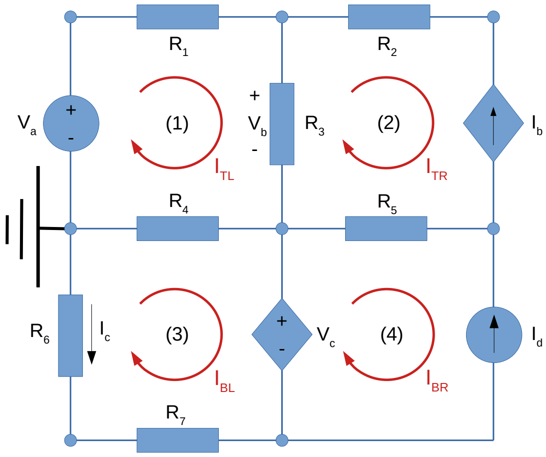

Figure 2: Circuit with clockwise assigned current directions

After identifying the mesh currents, we will use the Kirchhoff Voltage Law (KVL) in the meshes that do not contain current sources, (1) and (2), and to equal the mesh currents to the currents imposed by the sources in the other two, (3) and (4):

$$R_1 I_t l + V_b + R_4(I_t l - I_b l) - V_a = 0 \tag{1}$$

$$V_c + I_b l(R_4 + R_6 + R_7) - R_4 I_t l = 0 \tag{2}$$

$$I_t r = -I_b \tag{3}$$

$$I_b r = -I_d \tag{4}$$

We can find another 4 independent equations to solve the circuit. These are either given to us, (5) and (6), or can be extracted by direct analyses of the circuit with Ohm's Law, (7) and (8):

$$I_b = K_b V_b \tag{5}$$

$$V_c = K_c I_c \tag{6}$$

$$I_c = -I_b l \tag{7}$$

$$V_b = R_3(I_\alpha - I_\beta) \tag{8}$$

Using Octave we can arrange a matrix to find the solution to the linear system:

Name	Value [A or V]
$@I_{tl}$	2.671902e-04
$@I_{tr}$	2.800095e-04
$@I_{bl}$	-1.010603e-03
$@I_{br}$	-9.340051e-04
V_b	-3.927010e-02
V_c	7.809141e+00
$@I_b$	-2.800095e-04
$@I_c$	9.340051e-04

Table 1: Variables in the Mesh Method. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

2.2 Nodal Method

To apply the Nodal Method (KCL) we need to first identify all the nodes, Figure 3. The Nodal Method depends on the principle that all the sum of the converging and diverging currents in a certain node must be zero. This means that the sum of the current that flows into a specific node minus the current that flows out of this node should be zero for any node in the circuit.

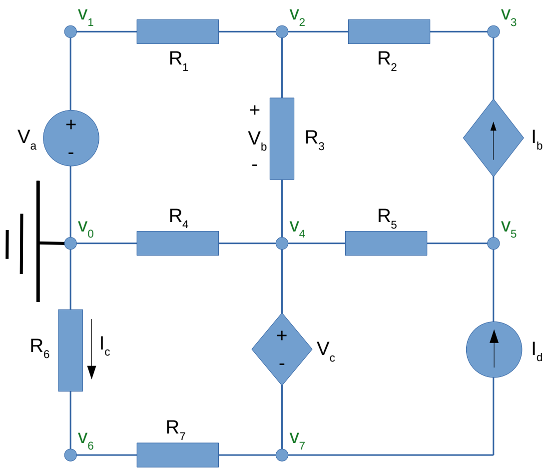

Figure 3: Circuit with numbered nodes, voltages relative to v0

After finding all the nodes we now assigne a number, and an unknown voltage based on the comparision with the voltage of node 0 (v0=0V). To start solving the circuit we have to use the Kirchoff Current Law (KCL) to all the nodes that do not have a voltage source connected to them, in node 2 (9), 3 (10), 5 (11) and 6 (12):

$$\frac{v_2 - v_1}{R_1} + \frac{v_2 - v_3}{R_3} + \frac{V_b}{R_3} = 0; \tag{9}$$

$$I_b + \frac{v_2 - v_3}{R_2} = 0 \tag{10}$$

$$\frac{v_4 - v_5}{R_5} - I_b + I_d = 0 \tag{11}$$

$$I_c + \frac{v_7 - v_6}{R_7} = 0 \tag{12}$$

For the voltage sorces we can write equations that relate them with the voltage assigned to the nodes, (13) and (14):

$$v_1 - v_0 = V_a \tag{13}$$

$$v_4 - v_7 = V_c \tag{14}$$

The dependent current source and voltage source equations can also be used to solve the system, (15) and (16):

$$V_c = K_c I_c \tag{15}$$

$$I_b = K_b V_b \tag{16}$$

Using Ohm's Law, we find the relation (17), and by direct analysis we can also write (18):

$$I_c = \frac{v_0 - v_6}{R_6} \tag{17}$$

$$v_b = v_2 - v_4 \tag{18}$$

We also define v0 as tne node connected to ground, as previously mentioned, (19):

$$v_0 = 0. \tag{19}$$

Because we need one more equation to solve the linear system we take advantage of the fact that the voltage sources don't alter the current, and so we can treat nodes 0 and 1 as one big node to write the equation, (20):

$$\frac{v_4 - v_0}{R_4} + \frac{v_2 - v_1}{R_1} - I_c = 0; \tag{20}$$

Now we use octave to determine the final solution of the system:

Name	**Value [A or V]**
v_0	0.000000e+00
v_1	5.211160e+00
v_2	4.942284e+00
v_3	4.369779e+00
v_4	4.981554e+00
v_5	8.916754e+00
v_6	-1.870841e+00
v_7	-2.827587e+00
V_b	-3.927010e-02
V_c	7.809141e+00
@I_b	-2.800095e-04
@I_c	9.340051e-04

Table 2: Variables in the Nodal Method. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

3 Simulation Analysis

3.1 Operating Point Analysis

Table 3 shows the simulated operating point results for the circuit under analysis.

Name	Value [A or V]
@gb[i]	-2.80010e-04
@id[current]	1.010603e-03
@r1[i]	2.671902e-04
@r2[i]	2.800095e-04
@r3[i]	-1.28194e-05
@r4[i]	-1.20120e-03
@r5[i]	-1.29061e-03
@r6[i]	9.340051e-04
@r7[i]	9.340051e-04
v(1)	5.211160e+00
v(2)	4.942284e+00
v(3)	4.369779e+00
v(4)	4.981554e+00
v(5)	8.916754e+00
v(6)	-1.87084e+00
v(7)	-2.82759e+00
v(8)	0.000000e+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.

4 Conclusion

The objective of this Laboratory of analysing a simple circuit, consisting only of voltage and current sources as well as resistors has been concluded. We successfully made both the theoretical and practical analysis of the circuit T1 and were now expecting to take some conclusions, calculate errors and show interesting data regarding the work we have just finished. Unfortunetly, our attempt to calculate any sort of errors was stopped by the inexistence of any. Both the theoretical and practical attempts have a perfect match of values of current and voltage in any studied element of the circuit. So if we can't take conclusions about errors, we can at least think of a reason to why there are none. Well, as this laboratory was made with a simulated software machine, and the circuit is very simple it is easy to see why there would be no errors. The circuit is pretty straightforward, it doesn't have any components that depend on time that could lead to aproximate models for calculating any quantaty, so it eliminates any kind of error by aproximation. Also, the ngspice software uses perfect resistors, as well as wires with no resistence to connect the components, and voltage sources with no internal resistance, so that there is no unwanted Joule Efect in the circuit, as it would be a factor in a real experiment in laboratory. So, all the mistakes that could exist would have to be made by us. This explanation ends our conclusion and also our laboratory T1 report.