Circuit Theory and Electronics Fundamentals

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Example Laboratory Report

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Contents

1 Introduction

The objective of this laboratory assignment is to study a circuit containing resistors that follow Ohm's law, independent and linearly dependent voltage and current sources. With this analysis, we want to determine the potential at each of the eight nodes and the current flowing through all of the ten branches. With this purpose, we'll use both node method, that is, the usage of KVL theorem at all the nodes, considering the voltage of the nodes, and mesh method, that is, applying KCL theorem in all of the four meshes, each one with a current defined by us. (De mais??)

The circuit explained, as well as all numbered nodes and mesh currents, can be seen in Figure.

In Section, a theoretical analysis of the circuit is presented. In Section sec:simulation, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section sec:analysis. The conclusions of this study are outlined in Section sec:conclusion. (De menos? dizer que vamos uma continuação do que dissemos no inicio na parte teórica)

2 Theoretical Analysis

In this section, the circuit shown earlier in Figure **??** is analyzed, using both node and mesh methods, as explained in section **??**. It is important to notice that node 0 corresponds to ground, meaning we assign it has having null potential.

**tabela com os valores

2.1 Node method

Using Kirchhoff Current Law (KCL) at all nodes, we end up with these equations:

$$\begin{cases} I_d = \frac{V_1 - V_6}{R_5} + I_b \\ I_b = \frac{V_2 - V_3}{R_2} \\ \frac{V_2 - V_3}{R_2} = \frac{V_3 - V_4}{R_1} + \frac{V_b}{R_3} \\ V_4 - V_5 = V_a \\ \frac{V_6 - V_5}{R_4} = \frac{V_5 - V_7}{R_1} + \frac{V_4 - V_3}{R_1} \\ V_6 = V_c \\ \frac{V_5 - V_7}{R_6} = \frac{V_7}{R_7} \\ I_b = K_b V_b = K_b (V_3 - V_6) \\ V_c = K_c I_c = K_c \frac{V_5 - V_7}{R_6} \end{cases}$$

Where V_i represents the voltage at node i.

Substituting variables by their numeric number given in table **, and solving this sistem of linear equations using *Octave*, we end up with: **results**

We can get the current flowin through each branch using Ohm's law (Mostrar tabelas com as correntes ou não é necessário?)

2.2 Mesh method

Using Kirchhoff Voltage Law (KVL) in all meshes, we can write these equations:

$$\begin{cases} R_1 I'_A + R_3 (I'_A + I'_B) + R_4 (I'_A + I'_C) = V_a \\ I'_B = I_b = K_b V_b = K_b R_3 (I'_A + I'_B) \\ R_4 (I'_A + I'_C) + R_6 I'_C + R_7 I'_C = K_c I_c = K_c I'_C \\ I'_D = -I_d \end{cases}$$

The circuit consists of a single V-R-C loop where a current $i(t)$ circulates. The voltage source $v_I(t)$ drives its input, and the output voltage $v_O(t)$ is taken from the capacitor terminals. Applying the Kirchhoff Voltage Law (KVL), a single equation for the single loop in the circuit can be written as

$$Ri(t) + v_O(t) = v_I(t). \tag{1}$$

Because v_O is the voltage between capacitor C's plates, it is related to the current i by

$$i(t) = C \frac{dv_O}{dt}. \tag{2}$$

Hence, Equation (1) can be rewritten as

$$RC \frac{dv_O}{dt} + v_O(t) = v_I. \tag{3}$$

Equation is a linear differencial equation whose solution is a superposition of a natural solution v_{On} and a forced solution v_{Of}:

$$v_O(t) = v_{On}(t) + v_{Of}(t). \tag{4}$$

As learned in the theory classes the natural solution is of the form

$$v_{On}(t) = Ae^{-\frac{t}{RC}}, \tag{5}$$

where A is an integration constant.

The forced solution is of the form given in Equation and is illustrated in Figure.

$$V_{Of}(t) = |\bar{V}_{Of}|cos(\omega t + \angle\bar{V}_{Of}), \tag{6}$$

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3 Frequency response

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4 Simulation Analysis

4.1 Operating Point Analysis

Table tab:op 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.

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Name	Value [A or V]
I'_A	0.000280737730604
I'_B	-0.000294385330347
I'_C	0.000969408567879
I'_D	-0.001038309112650

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.

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4.2 Transient Analysis

Figure fig:trans shows the simulated transient analysis results for the circuit under analysis. Compared to the theoretical analysis results, one notices the following differences: describe and explain the differences.

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4.3 Frequency Analysis

4.3.1 Magnitude Response

Figure fig:acm shows the magnitude of the frequency response for the circuit under analysis. Compared to the theoretical analysis results, one notices the following differences: describe and explain the differences.

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4.3.2 Phase Response

Figure **??** shows the magnitude of the frequency response for the circuit under analysis. Compared to the theoretical analysis results, one notices the following differences: describe and explain the differences.

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4.3.3 Input Impedance

Figure fig:zim shows the magnitude of the frequency response for the circuit under analysis. Compared to the theoretical analysis results, one notices the following differences: describe and explain the differences.

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5 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.

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