Circuit Theory and Electronics Fundamentals

Department of Electrical and Computer Engineering, Técnico, University of Lisbon

T1's Laboratory Report

Carlos Ribeiro (96364), João Diniz (96416), Paulo Clemente (96462)

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1 Introduction

The objective of this laboratory assignment is to study a given circuit, described in the figure 1 below, running a theoretical analysis as well as a simulation and compare both of the results.

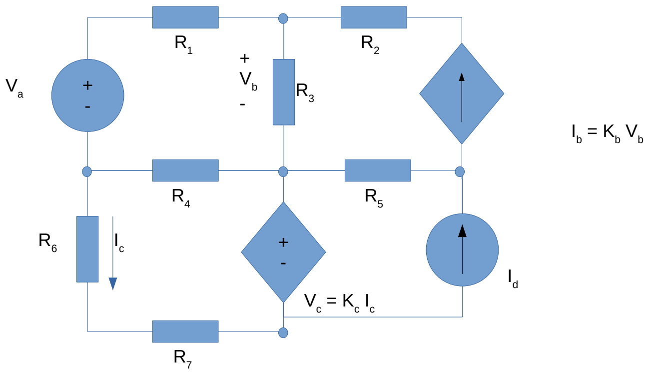

Figure 1: T1's given circuit.

The theoretical analysis will be done using both the mesh method as well as the nodal method. For the simulation, it will be done using a simple script on Ngspice.

The comparison between the three results will be made in the "Analysis" section of this report, where we will explain the small differences that we may get in our results.

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, this is, we will be using both the mesh method and the nodal method to calculate the remaining variables (I_a, I_b, I_c, V_b and V_c).

2.1 Mesh Method

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

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 (3) 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 (6) and is illustrated in Figure 2.

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

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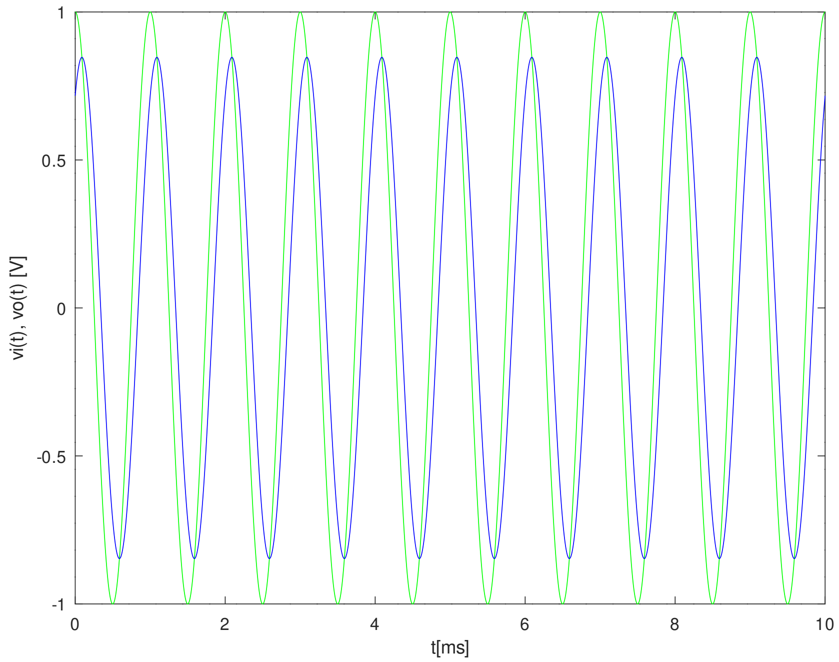

Figure 2: Forced sinusoidal response.

3 Frequency response

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4 Simulation Analysis

4.1 Operating Point Analysis

Table 1 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.

Name	**Value [A or V]**
@cb[i]	0.000000e+00
@ce[i]	0.000000e+00
@q1[ib]	7.022567e-05
@q1[ic]	1.404513e-02
@q1[ie]	-1.41154e-02
@q1[is]	5.765392e-12
@rc[i]	1.411536e-02
@re[i]	1.411536e-02
@rf[i]	7.022567e-05
@rs[i]	0.000000e+00
v(1)	0.000000e+00
v(2)	0.000000e+00
base	2.254108e+00
coll	5.765392e+00
emit	1.411536e+00
vcc	1.000000e+01

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 3 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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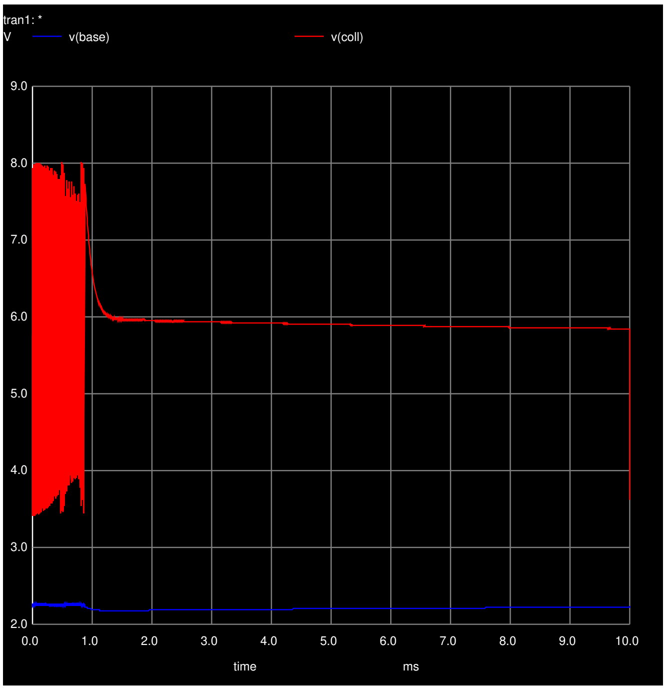

Figure 3: Transient output voltage

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4.3 Frequency Analysis

4.3.1 Magnitude Response

Figure 4 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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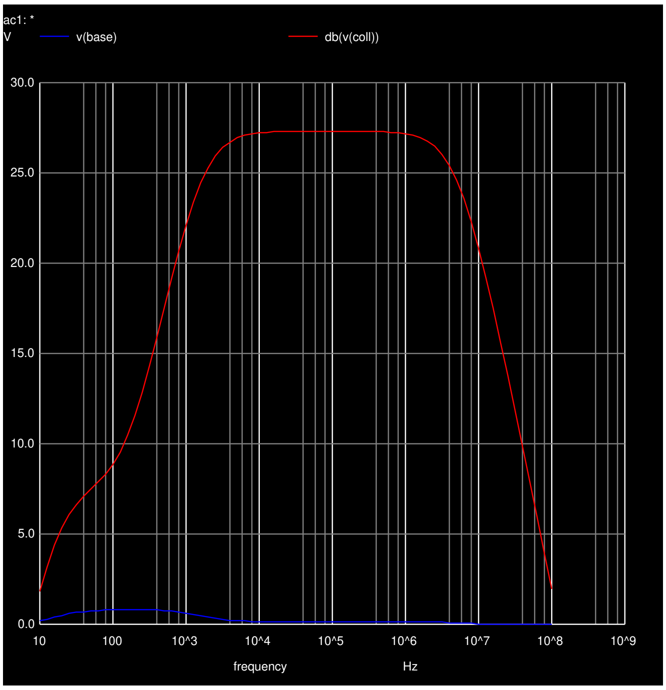

Figure 4: Magnitude response

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4.3.2 Phase Response

Figure 5 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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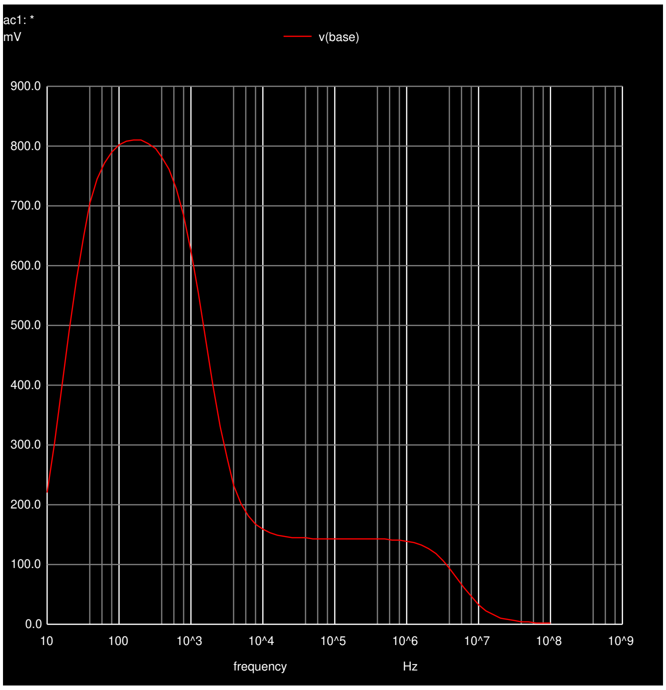

Figure 5: Phase response

4.3.3 Input Impedance

Figure 6 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

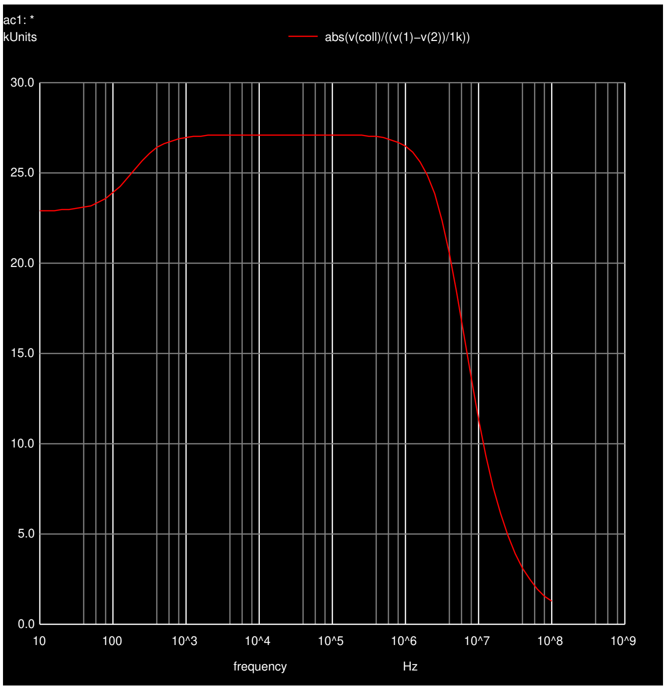

Figure 6: Input impedance

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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