Laboratory 1: Circuit Analysis Methods

Msc. Aerospace Engineering, Técnico, University of Lisbon

Circuit Theory and Electronics Fundamentals

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Contents

1 Introduction

The laboratory assignment presented has of its purpose the study of a circuit structured in four elementary meshes, through which exist seven resistors R_i, a voltage source V_a, a current controlled voltage source V_c, a current source I_d and a voltage controlled current source I_b. The circuit can be seen in Figure-1.

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Throughout the report it is presented a theoretical analysis, using both mesh and nods methods, in Section 2; an analysis of the circuit, in Section 5; a comparison of the results from both sections Section 2 and Section 5, in Section 2; and conclusions of the study, in Section 6.

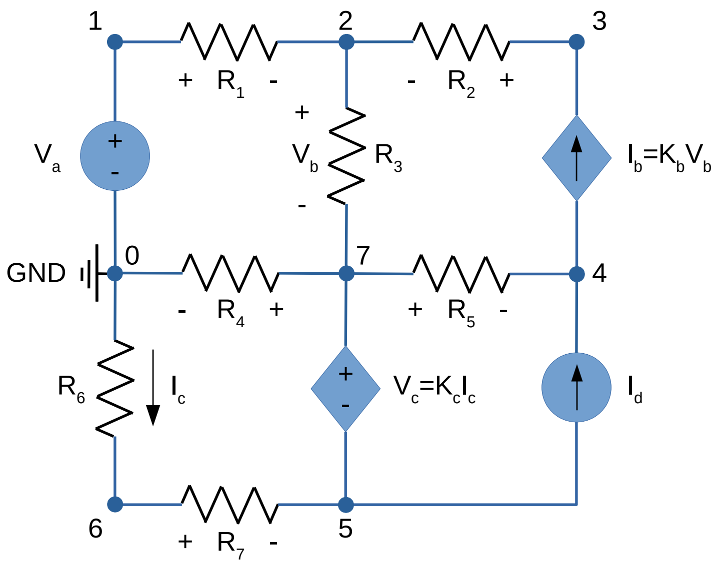

Figure 1: Voltage driven serial RC circuit.

2 Theoretical Analysis

In this section, the circuit shown in Figure **??** is analysed theoretically, in terms of its time and frequency responses.

3 Time response

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 (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 **??**.

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

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Name	**Value [A or V]**
I_b	-0.000226
I_d	0.001012
I_{R1}	0.000216
I_{R2}	-0.000226
I_{R3}	-0.000010
I_{R4}	0.001195
I_{R5}	-0.001238
I_{R6}	0.000978
I_{R7}	0.000978
V_1	5.125627
V_2	4.903891
V_3	4.446215
V_4	8.768409
V_5	-2.982745
V_6	-1.975719
V_7	4.934963

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.

4 Frequency response

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5 Simulation Analysis

5.1 Operating Point Analysis

Table 2 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]**
gib[i]	-2.26373e-04
id[current]	1.011815e-03
r1[i]	2.161226e-04
r2[i]	-2.26373e-04
r3[i]	-1.02499e-05
r4[i]	1.194589e-03
r5[i]	-1.23819e-03
r6[i]	9.784660e-04
r7[i]	9.784660e-04
v(1)	5.125627e+00
v(2)	4.903891e+00
v(3)	4.446215e+00
v(4)	8.768409e+00
v(5)	-2.98275e+00
v(6)	-1.97572e+00
v(7)	4.934963e+00
v(8)	-1.97572e+00

Table 2: 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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5.2 Transient Analysis

Figure **??** 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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5.3 Frequency Analysis

5.3.1 Magnitude 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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5.3.2 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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5.3.3 Input Impedance

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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6 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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