Circuit Theory and Electronics Fundamentals

MEAer (Integrated Master In Aerospace Engineering), Técnico, University of Lisbon

Laboratory 1: Circuit analysis methods

Group 3

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1 Introduction

The objective of this laboratory assignment is to study a circuit containing 4 independent meshes and a total of 11 branches: an independent voltage source V_A, an independent current source I_D, a dependent current source I_B, a dependent voltage source V_C and 7 resistances, from R_1 through to R_7. The circuit can be seen in Figure 1.

In Section 2, a theoretical analysis of the circuit is presented. In Section 4, 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 5.

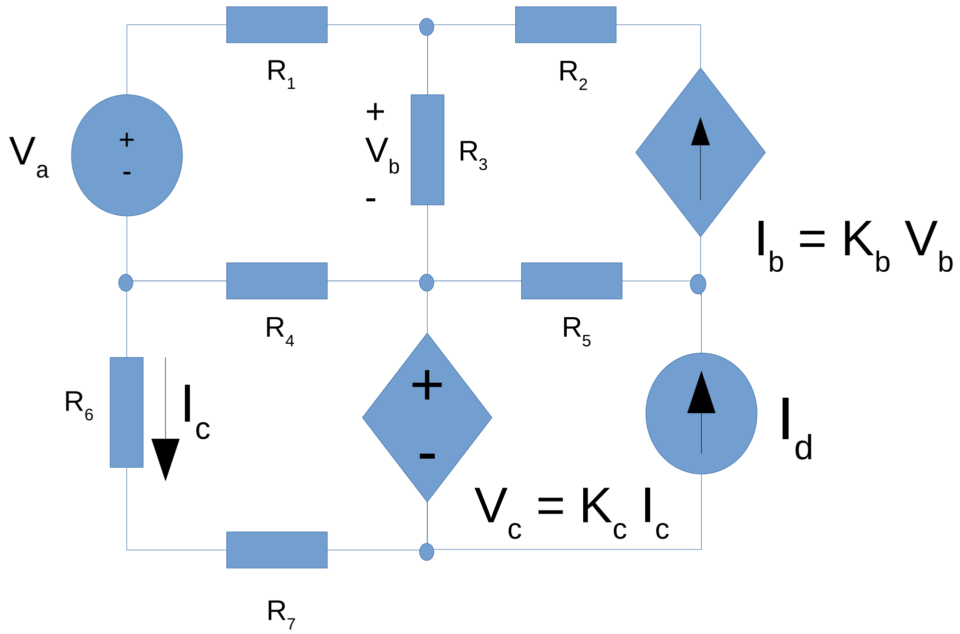

Figure 1: Circuit with linear components.

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, using both mesh and node analysis.

3 Mesh Analysis

The circuit consists of four independent loops, and 11 branches where different currents circulate. These will be our variables in the mesh analysis. The current flow is depicted in Figure 2

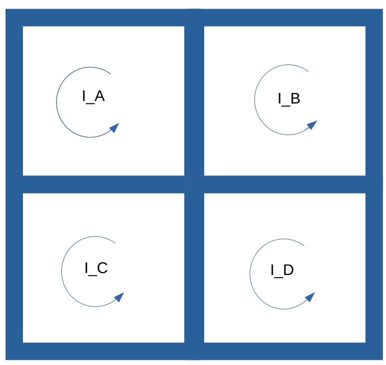

Figure 2: Direction of each mesh current.

Applying the Kirchhoff Voltage Law (KVL) in the different loops, we get four different equations which we can then solve as a matrix:

$$I_D = I; \tag{1}$$

$$(R_1 + R_3 + R_4)I_A - R_3 I_B - R_4 I_C = -V_A; \tag{2}$$

$$(R_4 + R_6 + R_7 - K_C)I_C - R_4 I_A = 0; \tag{3}$$

$$(R_3 K_B - 1)I_B - R_3 K_B I_A = 0. \tag{4}$$

$$v_O(t) = v_{On}(t) + v_{Of}(t). \tag{5}$$

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

$$v_{On}(t) = Ae^{-\frac{t}{RC}}, \tag{6}$$

where A is an integration constant.

$$V_{Of}(t) = |\bar{V}_{Of}|cos(\omega t + \angle \bar{V}_{Of}), \tag{7}$$

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]
@gb[i]	-2.29771e-04
@idd[current]	1.005042e-03
@r1[i]	2.191669e-04
@r2[i]	2.297712e-04
@r3[i]	1.060424e-05
@r4[i]	1.185502e-03
@r5[i]	1.234813e-03
@r6[i]	9.663347e-04
@r7[i]	9.663347e-04
v(1)	-9.73914e-01
v(3)	1.063433e+01
v(4)	6.382611e+00
v(5)	6.843347e+00
v(6)	7.067298e+00
v(7)	1.953900e+00
v(8)	6.875344e+00
v(9)	0.000000e+00

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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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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