TÉCNICO LISBOA

Circuit Theory and Electronics Fundamentals

T1 Laboratory Report

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March 22, 2021

Contents

1 Introduction

The objective of this laboratory assignment is to study a circuit containing independent and linearly dependent voltage and current sources. The circuit also contains 7 resistors, totaling 11 components that are conected both in series and in paralel.

The circuit has 7 nodes and 4 meshes. The nodes of the circuit were numbered arbitrarily (from *V0* to *V7*), and it was considered that *node 0* was the ground node. The voltage-controlled current source *Ib* has a linear dependence on Voltage *Vb* of constant *Kb*. The voltage *Vb* is the voltage drop at the ends of resistor *R3*. The current-controlled voltage source *Vc* has a linear dependece on current *Ic* of constant *Kc*. The control current *Ic* is the current that passes through the resistor *R6*. The circuit can be seen in Figure 1.

The values for the resistors, the independent sources and the constants for the dependent sources are presented in Table 1. These values were obtained using the Python script provided by the professor responsable for the laboratory assigment and using the number 95815 as the seed.

In Section 2, a theoretical analysis of the circuit is presented using two methodes: the mesh analisys and the nodal analysis. In Section 3, the circuit is analysed by simulation using the program Ngspice, and the results are compared to the theoretical results obtained in Section 2. The conclusions of this study are outlined in Section 4.

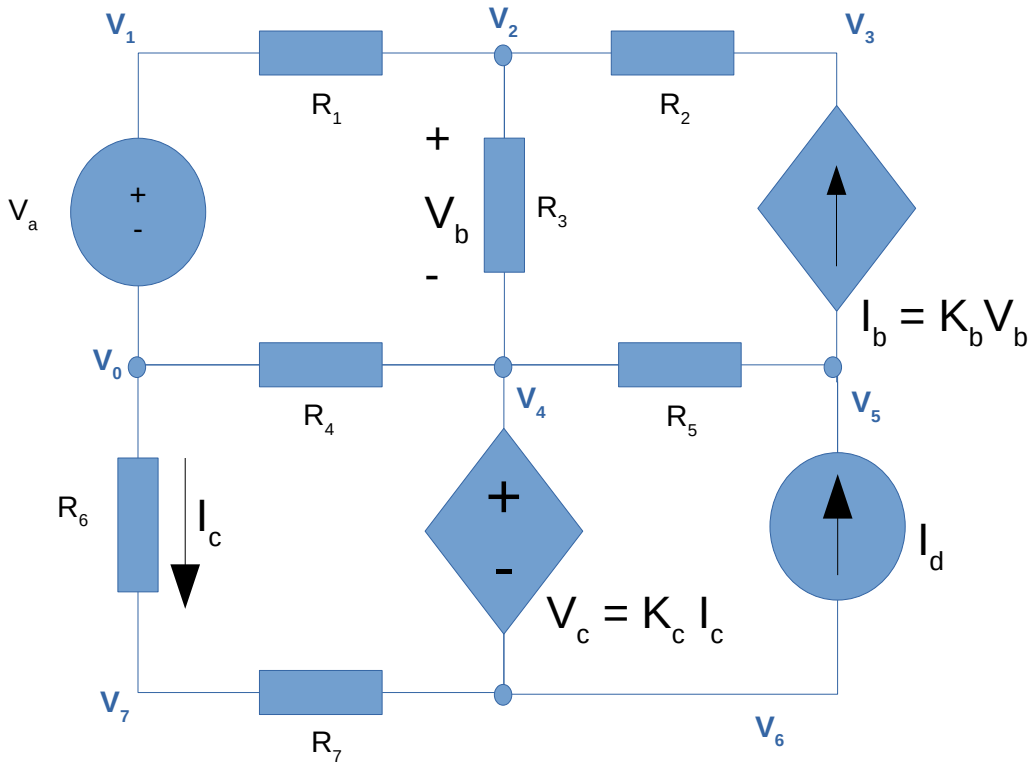

Figure 1: Circuit in study

Name	Python values
R1	1.04606282456
R2	2.00732621328
R3	3.06060705885
R4	4.07055531265
R5	3.1225213804
R6	2.06927045958
R7	1.01531018068
Va	5.24359648479
Id	1.01891541651
Kb	7.0473187437
Kc	8.3479788681

Table 1: The variables that starts with an *R* are the values of the resistors and are expressed in kiloohm (kOhm).The variable *Va* is a *voltage* and expressed in Volt (V) and the variable *Id* is a *current* and expressed in milliampere (mA).The constants *Kc* and *Kb* are expressed in kiloohm (kOhm) and millisiemens (mS) respectively.

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, using two methods: the mesh analysis and the nodal anaylis.

The circuit consists of a 6 resistors

MESH EQUATIONS

$$R_1 I_{SE} + R_3(I_{SE} + I_{SD}) + R_4(I_{SE} + I_{IE}) = Va$$

$$R_6 I_{IE} + R_7 I_{IE} + R_4(I_{IE} + I_{SE}) = K_c I_{IE}$$

$$I_{SD} = K_b R_3(I_{SE} + I_{SD})$$

$$I_{ID} = Id$$

NODAL EQUATIONS

$$V_0 = 0$$

$$V_8 = V_7$$

$$(V_1 - V_2)/R_1 + (V_0 - V_8)/R_6 + (V_0 - V_4)/R_4 = 0$$

$$(V_2 - V_4)/R_3 + (V_2 - V_3)/R_2 + (V_2 - V_1)/R_1 = 0$$

$$-K_b(V_2 - V_4) + (V_3 - V_2)/R_2 = 0$$

$$(V_5 - V_4)/R_5 + K_b(V_2 - V_4) - Id = 0$$

$$(V_7 - V_6)/R_7 + (V_7 - V_0)/R_6 = 0$$

$$V_1 - V_0 = V_a$$

$$V_4 - V_6 = K_c(V_0 - V_7)/R_6$$

Name	Mesh method	Node method
@Gb	-0.291567	-0.291567
@id	1.018915	1.018915
@r1	-0.278049	-0.278049
@r2	-0.291567	-0.291567
@r3	-0.013518	-0.013518
@r4	1.226887	1.226887
@r5	1.310482	1.310482
@r6	-0.948838	-0.948838
@r7	-0.948838	-0.948838
V1	5.243596	5.243596
V2	4.952740	4.952740
V3	4.367469	4.367469
V4	4.994112	4.994112
V5	9.086122	9.086122
V6	-2.926767	-2.926767
V7	-1.963402	-1.963402
V8	-1.963402	-1.963402

Table 2: A variable preceded by @ is of type *current* and expressed in milliampere (mA); other variables are of type *voltage* and expressed in Volt (V).

3 Simulation Analysis

3.1 Operating Point Analysis

Table 3 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 [mA or V]
@gb[i]	-2.91567e-01
@id[current]	1.018915e+00
@r1[i]	-2.78049e-01
@r2[i]	-2.91567e-01
@r3[i]	-1.35178e-02
@r4[i]	1.226887e+00
@r5[i]	1.310482e+00
@r6[i]	-9.48838e-01
@r7[i]	-9.48838e-01
v(1)	5.243596e+00
v(2)	4.952740e+00
v(3)	4.367469e+00
v(4)	4.994112e+00
v(5)	9.086122e+00
v(6)	-2.92677e+00
v(7)	-1.96340e+00
v(8)	-1.96340e+00

Table 3: Operating point. A variable preceded by @ is of type *current* and expressed in miliAmpere; other variables are of type *voltage* and expressed in Volt.

4 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.