Circuit Theory and Electronics Fundamentals

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1º Laboratory Report

March 25, 2021

Contents

1 Introduction

The objective of this laboratory assignment is to study a circuit containing a sinusoidal voltage source V_I connected to a resistor R and a capacitor C in series. The circuit can be seen if Figure 2.

In Section 2, a theoretical analysis of the circuit is presented. In Section 5, 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 6.

2 Theoretical Analysis

In this section, the circuit shown in Figure **??** is analyzed theoretically, by two different methods, which use the characteristics of the components present in the circuit and one of the two Kirch-

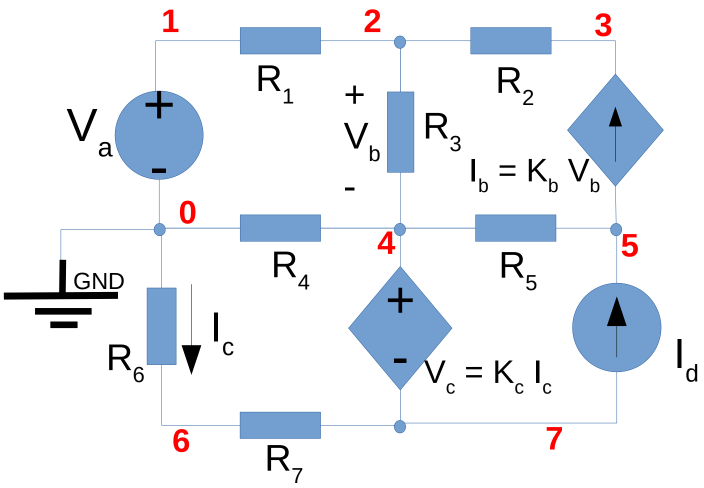

Figure 1: Voltage driven serial RC circuit.

hoff Laws. For the mesh method we used Kirchhoff's voltage law and for the nodal method we used Kirchhoff's current law. Besides the independent voltage sources and current sources, the other components of the circuit are, the resistors, which obey Ohm's law, and dependent voltage sources and current sources.

3 Mesh Method

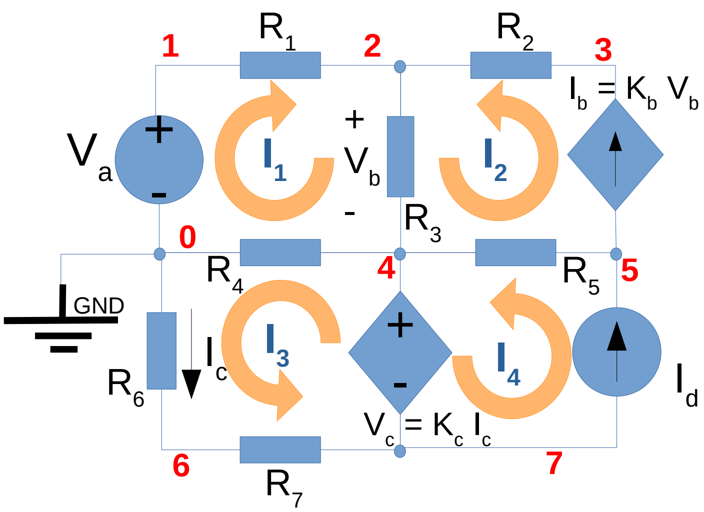

Figure 2: Voltage driven serial RC circuit.

To determine the values of V_a an V_b by applying Kirchhoff's voltage law, 4 equations are required. So the first equation can be writen as:

$$I_d = I_4. \tag{1}$$

Applying Kirxhhoff's Voltage Law (KVL) to equation (7) we get the following:

$$I3 = -\frac{R_4 I_1}{R_4 + R_6 + R_7 K_c}. \tag{2}$$

And

$$V_a(t) = (R_1 + R_3 + R_4)I_1 + R_4 I_3 R_3 I_2. \tag{3}$$

Knowing that:

$$I_2 = I_b, \tag{4}$$

And

$$v_b = \frac{I_b}{V_b} = \frac{I_2}{V_b} \tag{5}$$

We get:

$$I_1(R_3 K_b) + I_2(R_3 K_b - 1) = 0 \tag{6}$$

Name	**Value [A or V]**
@I1[i]	0.240224
@I2[i]	-0.251168
@I3[i]	0.968913
@I4[i]	1.038991
@G1[i]	-0.251168
@Id[current]	1.038991
@R1[i]	0.240224
@R2[i]	-0.251168
@R3[i]	-0.010944
@R4[i]	1.209137
@R5[i]	-1.290158
@R6[i]	0.968913
@R7[i]	0.968913

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 Nodal Method

In the nodal method, the circuit requires 6 equations to determine the values of V2, V3, V4, V5, V6, V7, which are obtained by applying Kirchhoff's current Law and a relation between the potential difference of two nodes and two other nodes, whose potential difference is imposed by a dependent voltage source.

Since we considered V_0 to be the ground, which means that V_o = 0 and therefore:

$$V_i = V_a. \tag{7}$$

We get the following equations by applying Kirchhoff's current law at different nodes:
For node 2 we have:

$$0 = V_1\frac{-1}{R_2} + V_1\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) + V_5\frac{-1}{R_2} + V_4\frac{-1}{R_3}. \tag{8}$$

Node 3:

$$0 = V_1(\frac{-1}{R_2} - K_b) + V_3\frac{-1}{R_2} + V_4(K_b). \tag{9}$$

Node 5:

$$I_d = V_2(K_b) + V_4(\frac{-1}{R_5} - K_b) + V_5\frac{1}{R_5}. \tag{10}$$

Node 6:

$$0 = V_6(\frac{1}{R_6} - \frac{1}{R_7}) + V_7\frac{-1}{R_7}. \tag{11}$$

Node 7:

$$0 = V_4 + V_6(\frac{K_c}{R_6}) - V_7. \tag{12}$$

And finally for node 4:

$$-I_d = V_2\frac{-1}{R_3} + V_4(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}) + V_5\frac{-1}{R_5} + V_6\frac{-1}{R_7} + V_7\frac{1}{R_7}. \tag{13}$$

Name	Value [A or V]
V(1)	5.239365
V(2)	4.988788
V(3)	4.482071
V(4)	5.023118
V(5)	8.995714
V(6)	-1.962948
V(7)	-2.972813
V(8)	0.000000

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.

5 Simulation Analysis

5.1 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.

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.

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.

Name	Value [A or V]
@g1[i]	-2.51168e-04
@id[current]	1.038991e-03
@r1[i]	2.402240e-04
@r2[i]	-2.51168e-04
@r3[i]	-1.09438e-05
@r4[i]	1.209137e-03
@r5[i]	-1.29016e-03
@r6[i]	9.689131e-04
@r7[i]	9.689131e-04
v(1)	5.239365e+00
v(2)	4.988788e+00
v(3)	4.482071e+00
v(4)	5.023118e+00
v(5)	8.995714e+00
v(6)	-1.96295e+00
v(7)	-2.97281e+00
v(8)	-1.96295e+00

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

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.

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.

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.