Circuit Theory and Electronics Fundamentals

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Laboratory Report: Lab Assignment T1

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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 1.

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 1 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

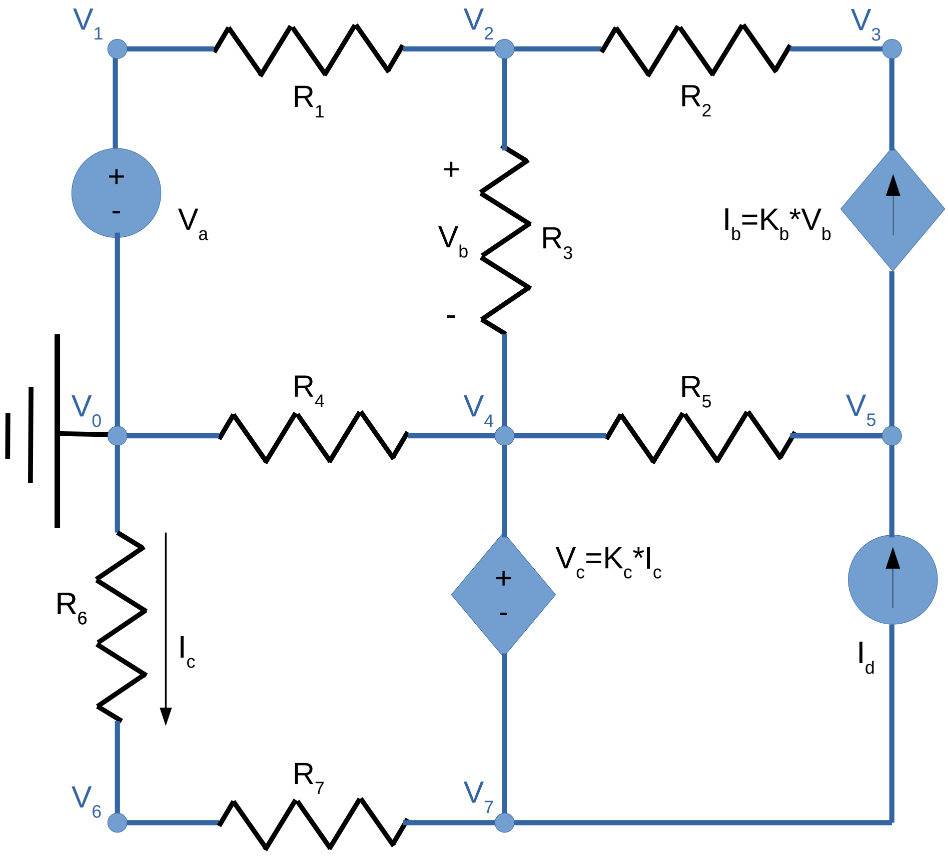

Figure 1: Voltage driven serial RC circuit.

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 [REDACTED].

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

4 Frequency response

5 Simulation Analysis

We decided to, once again, put the circuit's scheme down below, so as to make the interpretation of the following results easier.

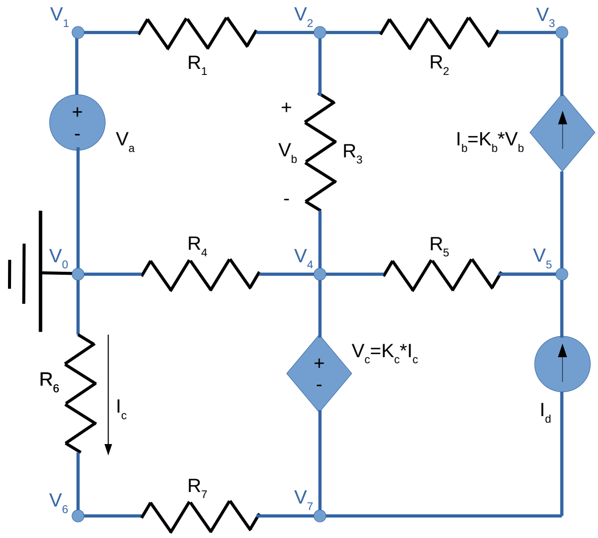

Figure 2: t1-Circuit scheme.

5.1 Operating Point Analysis

Table 1 shows the simulated operating point results for the circuit under analysis. As can be seen, we obtianed similar results to the ones calculated in the theoretical analysis section. This is proof that our theoretical analysis is, indeed, correct. We noticed, however, that *Octave* rounded the values of the circuit's parameters $(R_1, ..., R_7, V_a, I_d, K_b, K_c)$, whereas *Ngspice* operated with the same precision as the one provided initially (no rounding). As such, one could expect to find slightly different results. However, this did not prove to be the case.

Name	**Value [A or V]**
v(1)	5.021907e+00
v(2)	4.789309e+00
v(3)	4.308935e+00
v(4)	4.821580e+00
v(5)	8.641480e+00
v(6)	-1.90987e+00
v(7)	-2.84486e+00
@r1[i]	2.220120e-04
@r2[i]	2.323627e-04
@r3[i]	-1.03507e-05
@r4[i]	1.151862e-03
@r5[i]	-1.24218e-03
@r6[i]	9.298504e-04
@r7[i]	9.298504e-04
@hc[i]	7.997019e-05

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.

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.