

Circuit Theory and Electronics Fundamentals

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Example Laboratory Report

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1 Introduction

The objective of this laboratory assignment is to study a circuit containing a various resistors, two voltage sources and two current sources. The circuit can be seen if Figure 1.

In Section 2, a theoretical analysis of the circuit is presented. In Section 3, 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 4.

2 Theoretical Analysis

In this section, the circuit shown in Figure ?? is analysed theoretically, first we approach the circuit using the mesh analysis, and later we analyse the circuit using the nodal analysis.

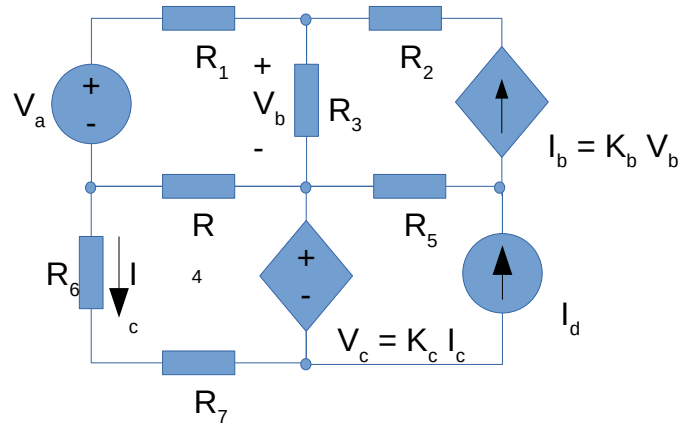


Figure 1: Circuit to be studied

2.1 Mesh Analysis

As seen during theoretical lessons, we can use a mesh analysis to analyse the circuit. This method is built upon Kirchhoff's Voltage Law that states:

In a mesh, the sum of all voltages equals 0.

$$\sum_{i=0}^n V_i = 0 \quad (1)$$

Because v_O is the voltage between capacitor C's plates, it is related to the current i by

$$i(t) = C \frac{dv_O}{dt}. \quad (2)$$

Hence, Equation (??) can be rewritten as

$$RC \frac{dv_O}{dt} + v_O(t) = v_I. \quad (3)$$

Equation (3) is a linear differential equation whose solution is a superposition of a natural solution v_{On} and a forced solution v_{Of} :

$$v_O(t) = v_{On}(t) + v_{Of}(t). \quad (4)$$

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

$$v_{On}(t) = Ae^{-\frac{t}{RC}}, \quad (5)$$

where A is an integration constant.

The forced solution is of the form given in Equation (6) and is illustrated in Figure 2.

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

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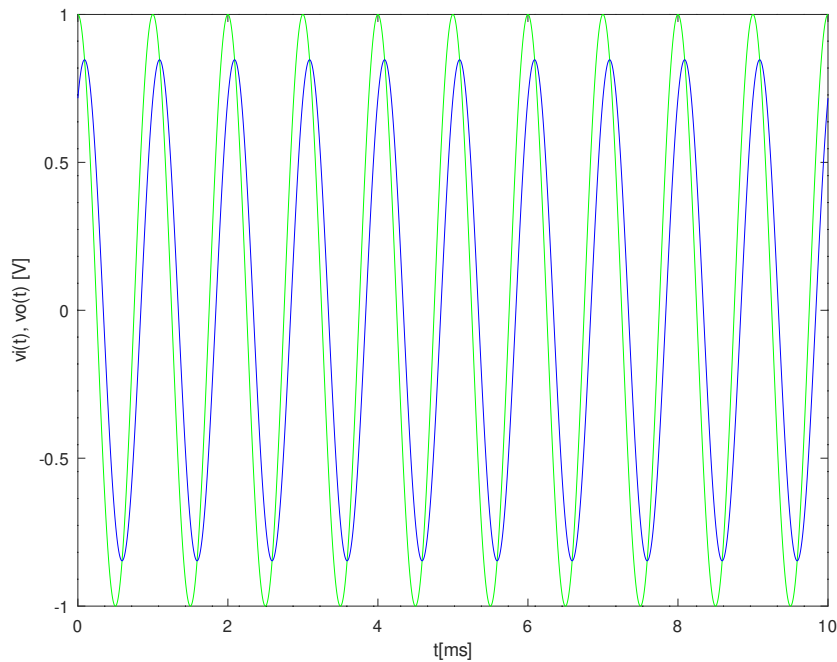


Figure 2: Forced sinusoidal response.

2.2 Nodal Analysis

3 Simulation Analysis

3.1 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.

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Name	Value [A or V]
@cb[i]	0.000000e+00
@ce[i]	0.000000e+00
@q1[ib]	7.022567e-05
@q1[ic]	1.404513e-02
@q1[ie]	-1.41154e-02
@q1[is]	5.765392e-12
@rc[i]	1.411536e-02
@re[i]	1.411536e-02
@rf[i]	7.022567e-05
@rs[i]	0.000000e+00
v(1)	0.000000e+00
v(2)	0.000000e+00
base	2.254108e+00
coll	5.765392e+00
emit	1.411536e+00
vcc	1.000000e+01

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.

3.2 Transient Analysis

Figure 3 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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3.3 Frequency Analysis

3.3.1 Magnitude Response

Figure 4 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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Figure 3: Transient output voltage

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3.3.2 Phase Response

Figure 5 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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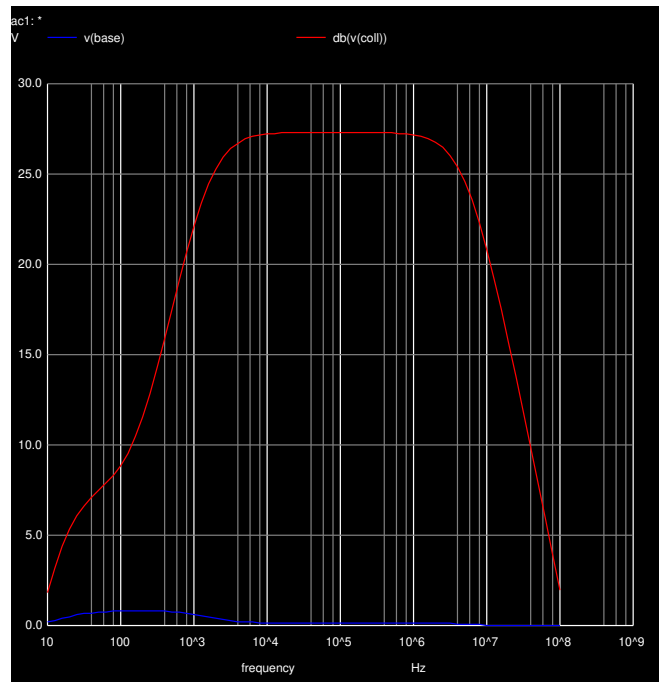


Figure 4: Magnitude response

3.3.3 Input Impedance

Figure 6 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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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

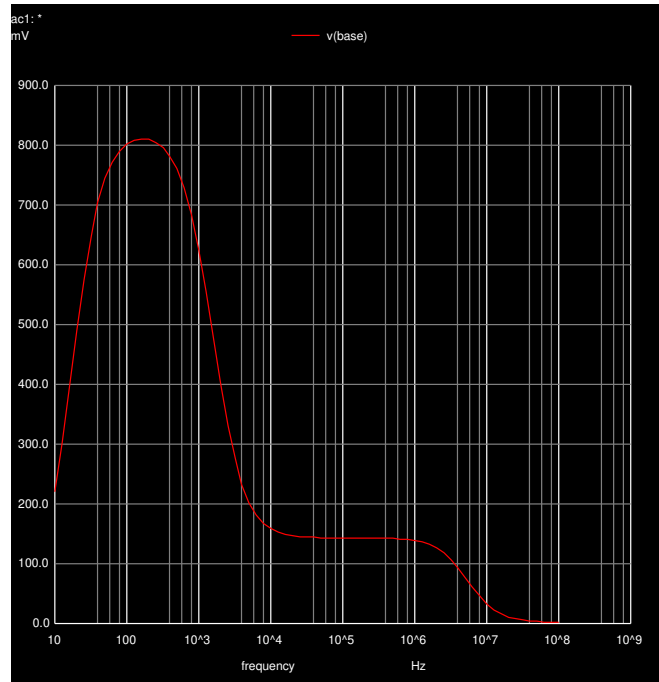


Figure 5: Phase response

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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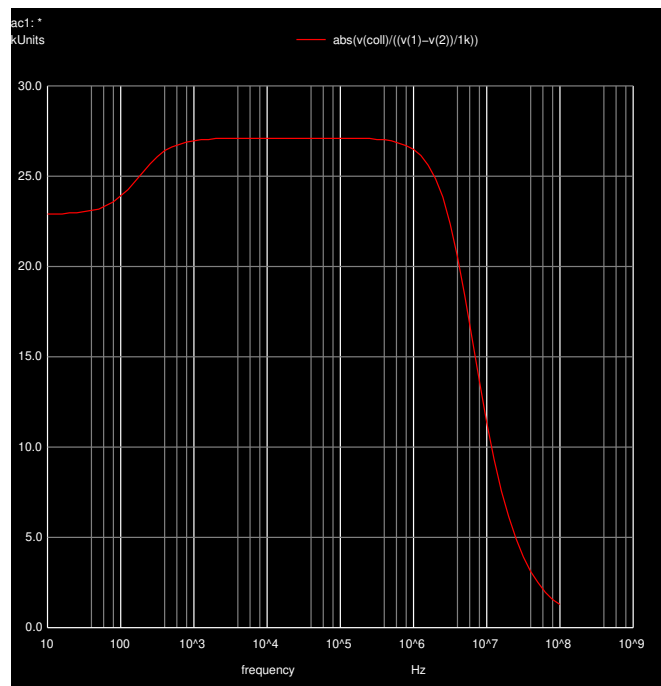


Figure 6: Input impedance