Circuit Theory and Electronics Fundamentals

Lab 3 - AC/DC Converter

Aerospace Engineering

Laboratory Report

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Contents

1   Introduction

This report is being made for the subject of Circuit Theory and Electronics Fundamentals and is related to the third laboratory being its objective to study an RC circuit containing seven resistors (from R_1 to R_7), one sinusoidal voltage source (v_s), one capacitor (C), one current controlled voltage source (V_d) and one voltage controlled current source (I_b). The four elementary meshes are named after the current to which they are attributed, and the nodes are named after the numbers attributed to them, being V_0 the ground node.

The current controlled voltage source V_d is calculated by multiplying K_d with the current I_d, whereas the voltage controlled current source I_b can be determined by multiplying K_b with the voltage source V_b.

The display of this circuit, as well as the equations used to determine the value of v_s, can be seen in Figure 1.

In Section 2 the circuit will be analysed theoretically with the aid of Octave, analysing firstly the circuit for $t < 0$ using the nodal method, calculating the equivalent resistence R_{eq} as seen from the capacitor terminals, determining the natural and forced solution for V_6 with the previous results, and finishing with the calculation of the frequency response for V_c, v_s and V_6 and the study of these results.

Secondly, in Section 3 it will be simulated the circuit using ngspice, with the aim of validating the results previously obtained by doing operating point, transient and frequency analysis.

Following with both results from Section 2 and Section 3 being compared and commented in Section **??**

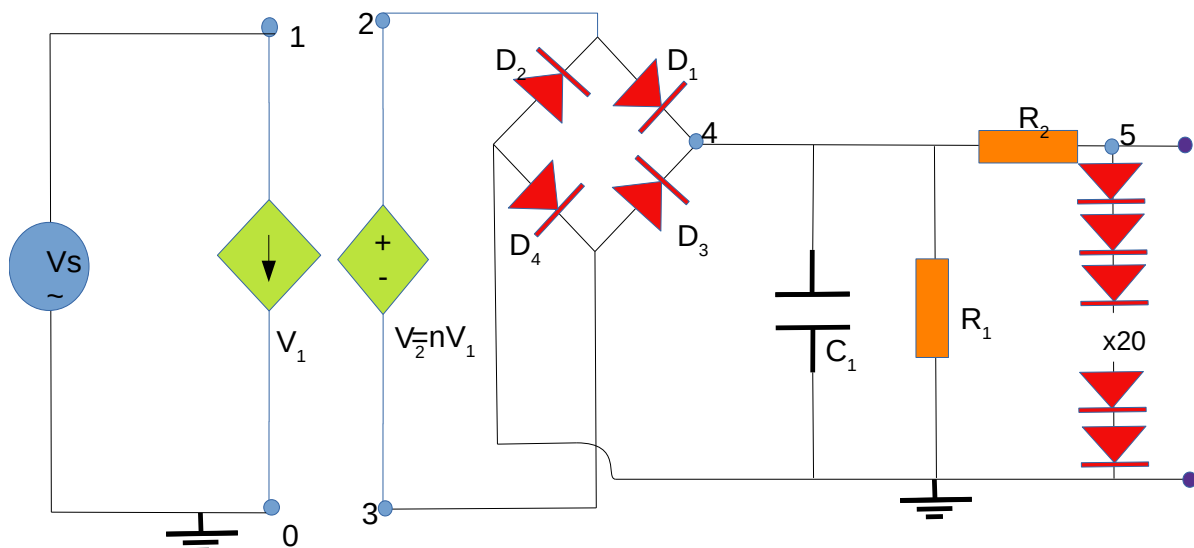The conclusions of this study are outlined in Section 4.

Figure 1: Circuit in analysis

The units of the elements whose name starts with R (the resistors) are Ω (ohm), V_s is expressed in V (volts) and C is given in F (farad). While K_b is given in S (siemens), K_d is also given in Ω.

These values where obtained using the Python script using the lowest student number on our group - 95785.

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, with the Nodal Analysis Method, which uses node voltages as the circuit

2.1 Natural Solution with node analysis for t$\geq$ 0

The aim of this section is to calculate the natural solution of $v_{6n}(t)$. Hence, the graph of V_{6n} in function of the time, in the interval [0;20] ms is represent in 2. The result is no suprise, as it shows below, being a negative exponential graph.
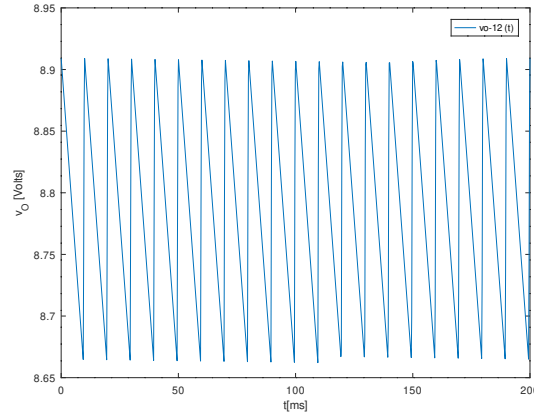

Figure 2: Natural solution $v_{6n}(t)$

2.2 Natural and Forced Superimposed

In this subsection, we determine the final total solution for the value of v_6 for the given

In Figure 3 we plotted the graphs of $v_6(t)$ and $v_s(t)$ in the interval [-5;20] ms. We can clearly divide the solutions in three parts:
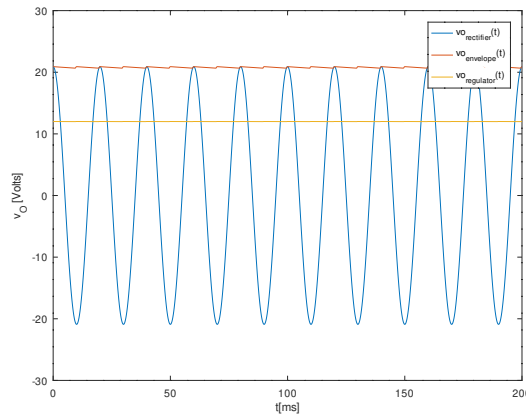

Figure 3: $v_s(t)$ and the final solution of $v_6(t)$ in the interval [-5;20]ms for the frequency of 1000Hz

3 Simulation Analysis

First of all, in this simulation is important to explain the creation of an auxiliary voltage V_{aux} (with a the same voltage of V_7) that was put between N7 and R7 as shown in Figure 4. Consequently, this led to the appearance of a node that we designated by N9 that has the same voltage as N7 (the drop voltage is 0).

   This was necessary because of Ngspice software requirements. After doing that ngspice was able to compute and determine all node voltages and current branches.
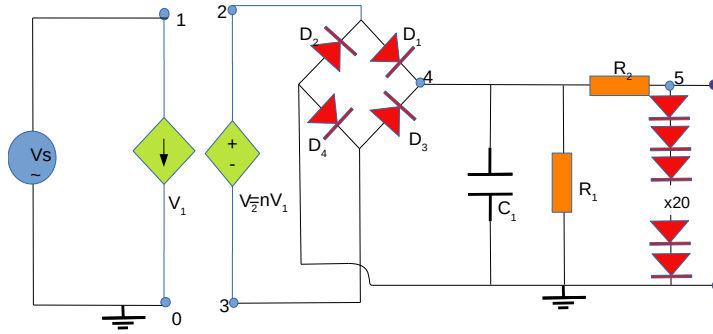

Figure 4: D Mesh with an additional voltage source

3.1 Operating Point Analysis for t<0

The Table 1 shows the simulated operating point results for the circuit described in Figure 1, considering t<0, which means $V_s(t)=V_s$.

Name	Value [A or V]
maximum(v(4))-minimum(v(4))	1.556516e-01
mean(v(4))	1.286552e+01
maximum(v(5))-minimum(v(5))	3.715695e-02
mean(v(5))	1.121846e+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 Operating Point Analysis for t=0

This second part covers the simulation of the circuit for t=0. To do that the capacitor is replaced with a voltage source $V_x = V_6 - V_8$ using the values obtained in the previous section. This is necessary because for t≤0 the voltage in the capacitor is the same. So to mantain the boundary conditions V_6 and V_8 the capacitor is replaced with the initial voltage source. The results are presented on Table 2.

Name	Value [A or V]
1/((maximum(v(5))-minimum(v(5)))*(mean(v(5)))+10e-6)	2.398923e+00

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.

3.3 Natural Solution

In order to study the natural solution response of the circuit in the interval [0;20]ms using the boundary conditions (V_6 and V_8) calculated before, a transient analysis was realized. Fig. 5 shows the plot of the required results.
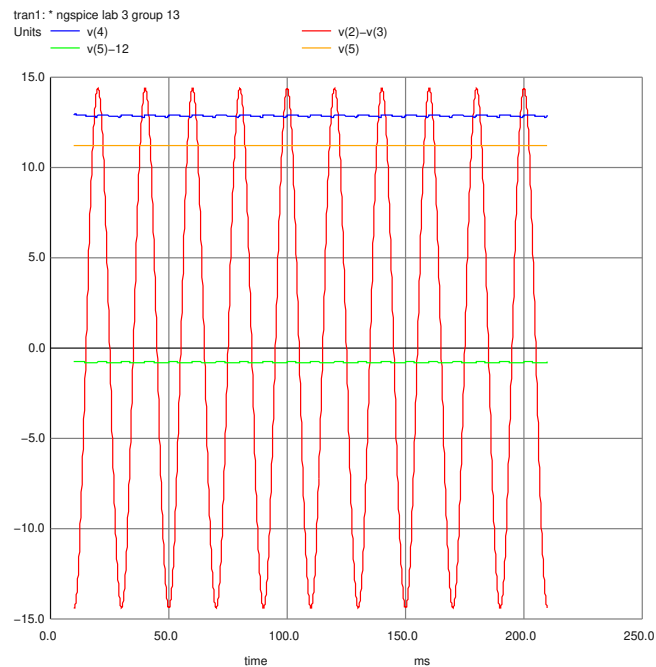

Figure 5: Natural Response of V_6

3.4 Total Solution

In the fourth section a total response of node 6 was perfomed, using the same procedure and interval of 3.3 with a initial sinusoidal voltage source $V_s(t)$ that has a frequency of 1000Hz. Fig. 6 shows the plot of the required results.
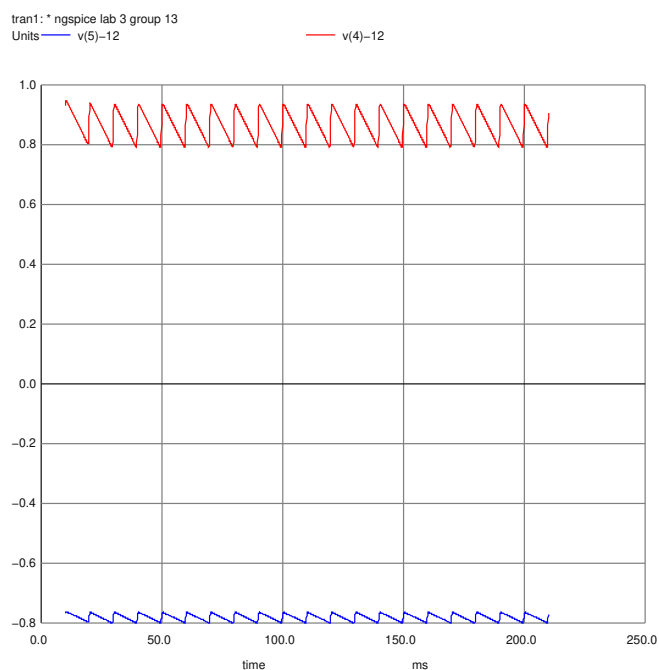

Figure 6: Total Response of V_6 and V_s

4 Conclusion

The objective of this laboratory assignment is to analyse the circuit and solve it. After discussing with all members of the group we can conclude that this goal was achieved.

As presented the results obtained by the Octave math tool and Ngspice simulation tool are the same. This perfect match was achieved in all the analysis done (operationg, transient and frequency) as presented in Section **??**.

Also, all the components used in this circuit (resistors, branches, nodes,...) are perfect this means they don't dissipate energy by heating.This is one of the advantages of simulating rather than doing it on the laboratory, the other one being the elimination of "humam error". It's known that this type of error can influence the experimental results causing considerable relative errors, which in our case weren't made.

Finally, this similarity proves the efficiency and precision of the methods that were used.