Instituto Superior Técnico, University of Lisbon

Integrated Master in Aerospace Engineering

Circuit Theory and Electronics Fundamentals

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First Laboratory Report

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Contents

1 Introduction **1**

2 Theoretical Analysis **2**
2.1 Envelope Detector 2
2.2 Voltage Detector 2
2.3 Voltage Regulator Circuit 2

3 Simulation Analysis **3**
3.1 Operating Point Analysis 3

4 Conclusion **4**

1 Introduction

The objective of this laboratory assignment is to build a AC/DC connverter.

V_{in}	2.300000e+02 V
f	5.000000e+01 Hz
n	1.120349e+01
R_1	6.000000e+04 Ohm
R_2	6.000000e+04 Ohm
C	1.000000e-04 F

Table 1: Data

In Section 2, a theoretical analysis of the circuit, performed on Octave, is presented. In Section 3, the circuit is analysed by simulation, using NGSpice, and the results are compared to the theoretical results obtained in Section 2. The conclusions of this study are outlined in Section 4.

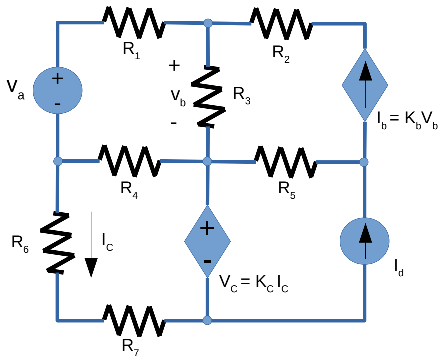

Figure 1: Circuit

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically. We will begin by analyzing the Envelope Detector circuit and, after that, the Voltage regulator circuit, in order to predict their outputs.

The theoretical values will be obtained by applying Kirchhoff laws and the diode equations. Considering the circuit of Figure 1, it is composed by a Voltage source, a transformer, an envelope detector and a voltage regulator.

The amplitude and the frequency of the voltage source are equal to 230V and 50Hz, respectively. However, the transformer will convert this into a lower voltage, supllying the rest of the circuit with a voltage, Vs(t):

$$V_s(t) = A \cdot cos(wt) \tag{1}$$

, where

$$w = 2 \cdot \pi \cdot f \tag{2}$$

It is important to notice that $A = (\frac{230V}{n})$. The value of the constant n was already indicated on Section 1.

2.1 Envelope Detector

The envelope detector consists of a rectifier, composed by four diodes, a resistor, R1, and a capacitor, C.

The rectifier used on this AC/DC converter was a full-wave rectifier, more specifically, a bridge rectifier. Theoretically, this rectifier produce an output of $V_(rectifier) = |V_s(t)|$.

The resistor and the capacitor are used to smooth the wave.

2.2 Voltage Detector

2.3 Voltage Regulator Circuit

The voltage regulator circuit takes advantage of the fact the diodes are non-linear components to attenuate the oscilations in the input signal without frequency dependence. In our case, the voltage regulator is composed by X diodes connect in series and one resistance with the value of R2.

The DC voltage in the regulator is the minimum between the average envelope and the voltage in each diode terminals times the number of diodes connected in series. Using the equation:

$$r_d = \frac{\eta \cdot V_T}{I_s \cdot \exp(\frac{V_d}{\eta \cdot V_t}} \quad (3)$$

, to compute the resistance seen by each diode terminals and calculate the AC voltage seen in the regulator. This means that the output DC voltage will be the sum of the AC voltage previously mentioned and the DC voltage previously mentioned, giving us the following graphics: *INSERIR GRÁFICOS* Ideally, the output DC voltage will be a constant equal to 12 Volts. And by analysing the graph and comparing it to the simulation we can conclude that it was /was not achieved a acceptable result.

3 Simulation Analysis

3.1 Operating Point Analysis

Table 2 shows the simulated operating point results for the circuit under analysis. Compared to the theoretical analysis results, we notice that the simulation results are accurate, except for the last decimal places, as a consequence of the cientific notation and the number of significative algharisms used by each program to present the results. Despite that, we realise that the values with more significant algharisms (used in NGSpice) match correctly the rounded values (used in Octave).

Name	Value [A or V]
@gb[i]	-2.10962e-03
@id[current]	1.040860e-03
@r1[i]	-2.01567e-03
@r2[i]	-2.10962e-03
@r3[i]	-9.39470e-05
@r4[i]	8.578007e-04
@r5[i]	3.150480e-03
@r6[i]	-1.15787e-03
@r7[i]	-1.15787e-03
v1	1.726209e+00
v2	-2.92429e-01
v3	-4.52814e+00
v4	9.535580e+00
v5	9.279827e-06
v6	-1.19150e+00
v7	-3.52221e+00
v8	-1.19150e+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.

In the table, we can see an nineth node (node 8), which has the same voltage value as node 6. This happens because, in NGSPice, when we want to simulate circuits with current-dependent sources, we must add a 0V voltage source in series to a component to sense the current flowing through it. Therefore, an aditional node appears in the simulated circuit.

Note that we can not perform aditional simulation analysis, namely transient and frequency ones, with phase and magnitude responses and input impedance, because the circuit does not have any electrical component which output is a function of time.

4 Conclusion

In this laboratory assignment the objective of analysing a circuit with resistors, voltage sources and current sources by applying the Nodal and Mesh methods together with Kirchhoff's Circuit Laws and Ohm's Law has been achieved. The theoreticall analysis was performed with the help of the Octave math tool and the circuit simulation using the Ngspice tool. The simulation results matched the theoretical results perfectly. This happens mainly because the method used to obtain the theoretical results is the same method Ngspice uses to emulate the described circuit. Another reason why the results match perfectly is that the circuit was composed by simple components.For more complex components, the theoretical and simulation models may differ but it is not the case in this assignment.