Circuit Theory and Electronics Fundamentals

Department of Electrical and Computer Engineering, Técnico, University of Lisbon

Laboratory Four Report

Francisco Batista, 95792.
Miguel Jesus, 95833.
Pedro Monteiro, 96465.

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1 Introduction

The main goal of this laboratory assignment is to design a circuit of an audio amplifier and to analyse it theoretically, as well as simulating it using Ngspice.

To successfully create this circuit we had to architecture the gain stage and the output stage

We were also asked to analyse quantitatively the quality of the designed circuit using the Merit expression presented bellow.

$$Merit = \frac{VoltageGain * bandwidth}{Cost * CutoffFreq} \tag{1}$$

2 Simulation Analysis

Before proceeding the theoretycal analysis, we simulated the circuit via the Ngspice software in order to perfect our parameters‘ values.

To simulate the transistor behaviour, we utilized the NPN and the PNP models provided by the professor.

We performed transient and frequency analysis of the combined gain and output stages, that represent, respectively, the common emitter and collector amplifiers.

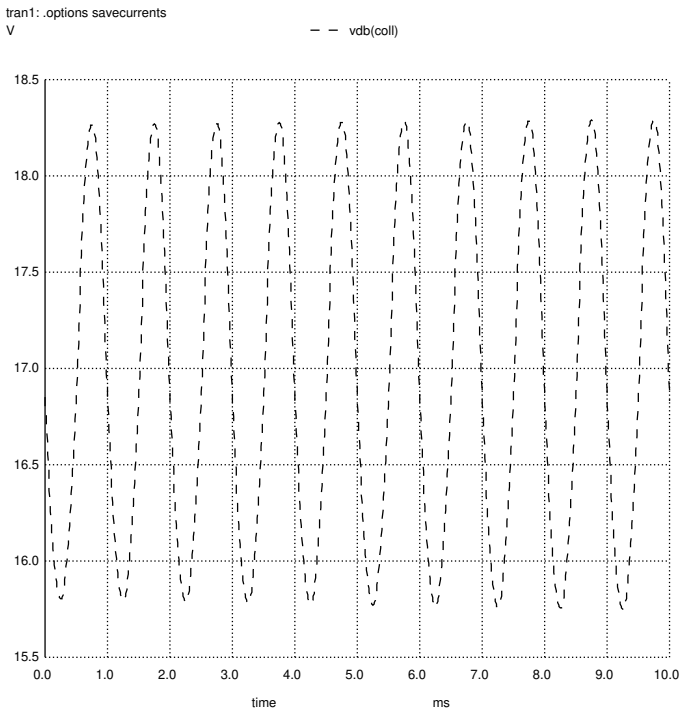

Figure 1: Voltage in the collector, transient analysis.

From the simulation we were able to compute the important values of the cut-off frequencies, the gain and the bandwidth, which allowed us to calculate our merit. Furthermore, we found the values for the input and output impedances.

3 Theoretical Analysis

In this section, we used the theorectical model as presented in the lectures. To do so we adopted the equations provided in lecture 16 and 17 and utilised the values of the circuit parameters, that we optimized with the help of Ngspice tool, as showcased previously.

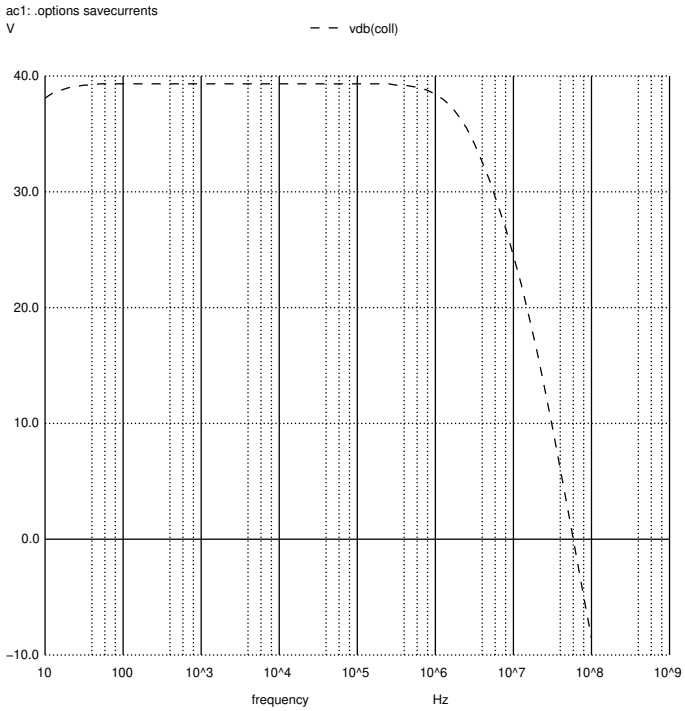

Figure 2: Voltage in the collector[dB], frequency analysis.

Parameters	**Values**
bandwidth	2.097646e+06
fup	2.097659e+06
flow	1.268798e+01
gain	7.175559e+01
merit	2.644085e+03
cost	4.486628e+03
impedin	9.895030e+01,-9.74274e-01

Table 1: Values computed in the simulation.

The circuit was divided in two main parts, the gain and output stages. These were combined together because they complemented one another.

The gain stage which consists of a common emitter amplifier has the advantage of generating a high, desirable gain. However, along with this comes the cost of having a very high output impedance which squanders the gain.

In order to reduce the high impedance value that is associated with the gain stage, we developed an output stage that allows to rectify the problem we had previously. Once again, we followed the instructions given in the lectures.

Finally, the gain results of the total circuit.

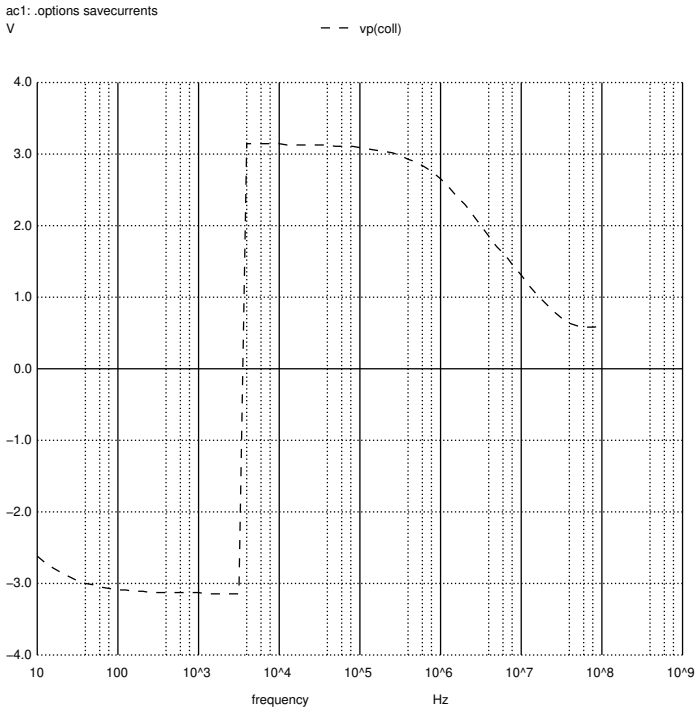

Figure 3: Phase voltage in the collector, frequency analysis.

Parameters	Values
impedout	7.818064e+04

Table 2: Output impedance.

4 Conclusion

To sum up, in this assignment, the main goal was successfully achieved. This objective was to analyze a circuit with varius components such as resistors, a voltage source that changes over time and a capacitor.

To perform this study we used the Octave and Ngspice tools for the theoretical and simulation analysis, respectively.

The values that were obtained in both analysis are very similar. nevertheless, there are small discrepancies between the sets of values. These differences are due to approximations, made particularly by Ngspice, as this software has a different level of digit precision when compared to Octave. Whereas some values in Octave are presented as 0, in Ngspice the same values are simulated with the order of 1e-14 or 1e-15 which we can consider to be also zero. Therefore the relative error between the theoretical and simulated results are very close to 0%.

The proximity between the values obtained in the static, time and frequency analysis in the theoretical and simulation section can be explained with the simplicity of the circuit that is only made of linear components and one capacitor.

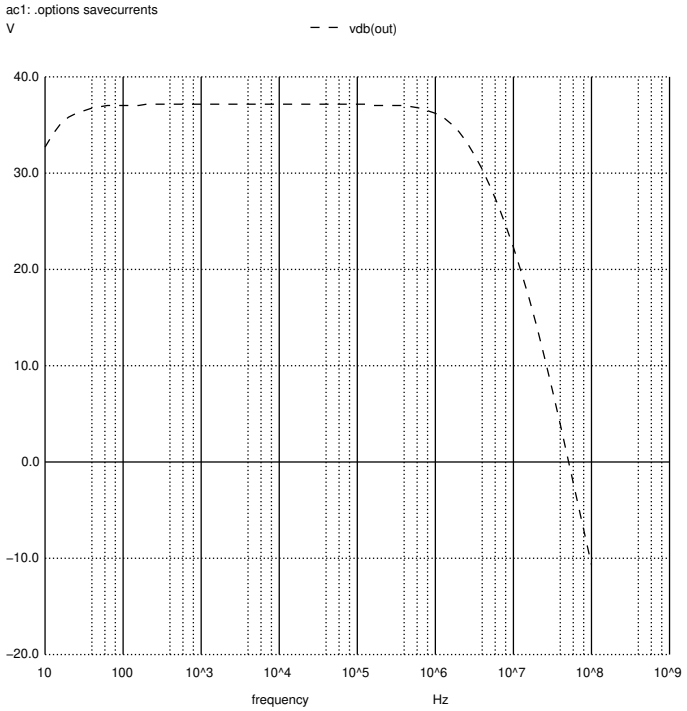

Figure 4: Output voltage[dB].

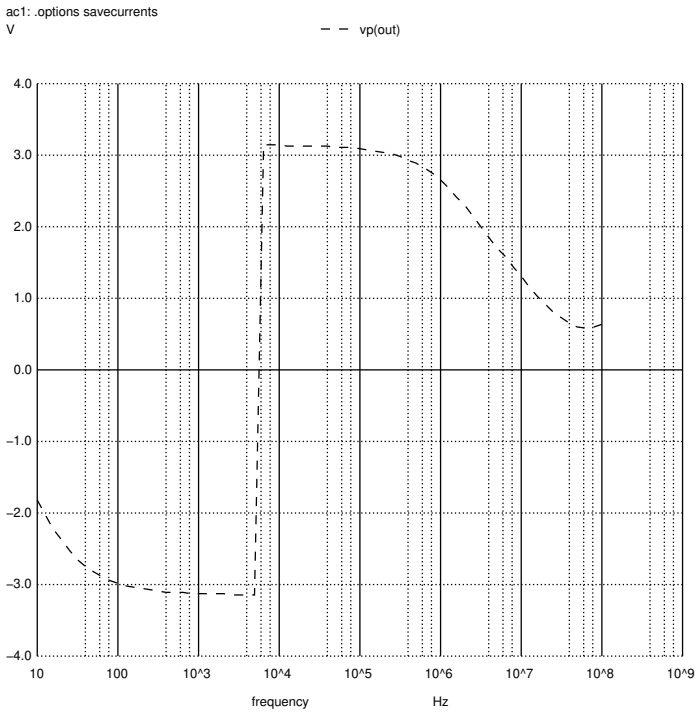

Figure 5: Output voltage phase.

Parameters	Values
—VT—	0.025000
—beta—	178.700000
—VA—	69.700000
—VBEON—	0.700000
—Vcc—	12.000000
—Req—	8461.538462
—Veq—	1.846154
—IB1—	0.000026
—IC1—	0.004613
—IE1—	0.004639
—V_{emit}—	0.927733
—V_{coll}—	6.925864
—VCE—	5.998131
—V_{base}—	1.627733

Table 3: Transistor‘s parameters.

Parameters	Values
—gm1—	0.184514
—ro1—	15109.960453
—rpi—	968.489933

Table 4: Parameters of slide 10, lecture 16.

Parameters	Values
—Input impedance—	869.023345
—Output impedance—	1025.354537
—Gain—	169.668298
—Gain(dB)—	44.592014

Table 5: Gain and impedances.

Parameters	Values
—VO2—	7.625864
—V_{coll}—	6.925864
—VA—	7.625864
—V_{emit}—	12.000000
—Vcc—	0.000087
—IB2—	0.019795
—IC2—	0.019882
—IE2—	

Table 6: Parameter values for the output stage.

Parameters	Values
—gm2—	0.791814
—go2—	0.000532
—gpi2—	0.003484
—ge2—	0.004545
—Input Impedance—	26837.230759
—Output Impedance—	1.249414
—Gain—	0.989304
—Gain(dB)—	-0.093408

Table 7: Output stage impedance and gain.

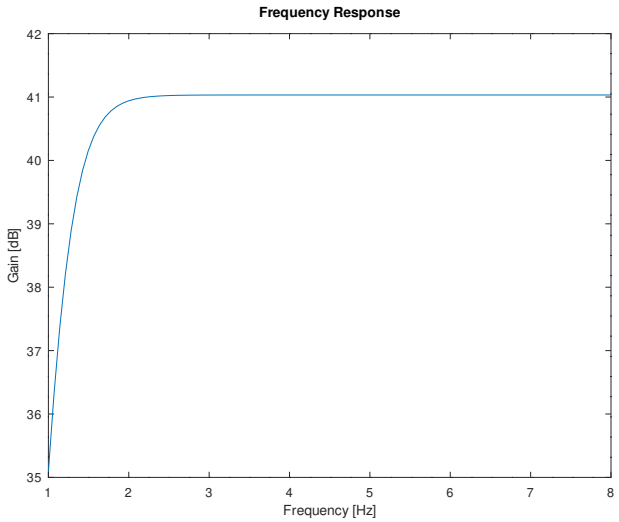

Figure 6: Plot of Gain in order of the Frequency (Hz).