TÉCNICO LISBOA

Circuit Theory and Electronics Fundamentals

Masters of Aeroespace Engineer, Técnico, University of Lisbon

Laboratory Report

Group 37

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1 Introduction

The objective of this laboratory assignment is to choose the best architecture of the Gain and Output amplifier stages in order to build an audio amplifier. This assignment allowed us to deal with important concepts such as BJTs Transistors and its diverse utility in circuits. We did this while paying attention to the merit of the project designed.
This merit is calculated exactly as the next equation:

$$M = \frac{voltageGain * bandwidth}{cost * lowerCutoffFreq} \tag{1}$$

Being the cost the following:

- cost = cost of resistors + cost of capacitors + cost of transistors
- cost of resistors = 1 monetary unit (MU) per kOhm
- cost of capacitors = 1 MU/μF
- cost of diodes = 0.1 MU per transistor

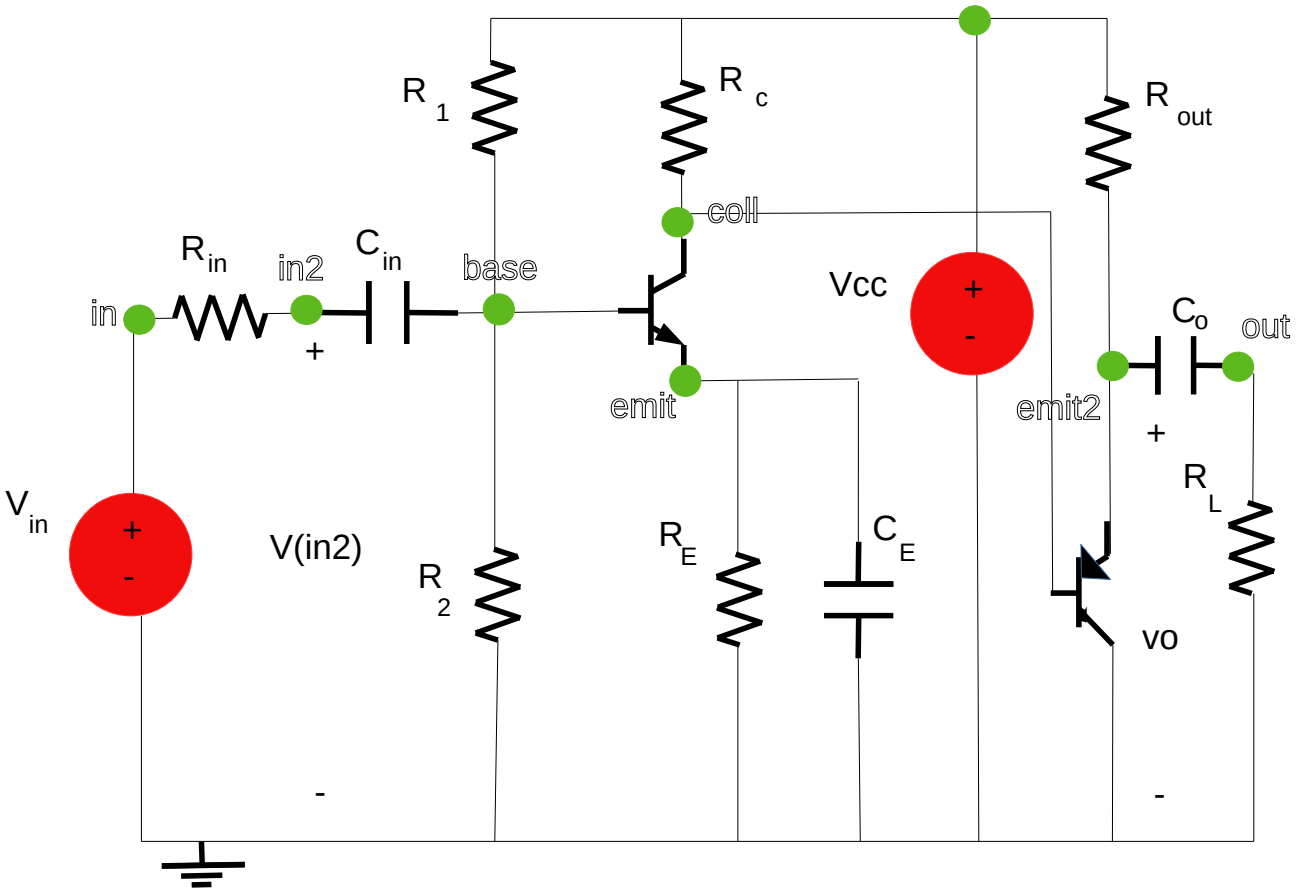

Figure 1: Audio Amplifier

To obtain the best values for the circuit, we've used the matlab simulink to optimize them for the best merit.

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 we will analyse theoretical our audio amplifier circuit.
To do so, and because there were several things to be analysed, we divided the theoretical analysis in the following subsections that explain the different sectors that our circuit has and also each one will be detailed separately.

The constants values used are expressed in the following table.

2.1 Gain Stage

In the first place, we must discuss the first half of the circuit that was used. The goal of the gain stage is to ensure a high input voltage so the input signal is not degradated or distorted throughout the circuit. It also has an elevated gain associated, so this is the part that is responsible for the signal amplification.

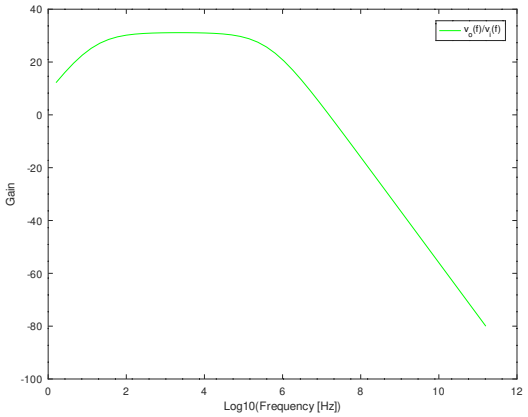

Figure 2: Gain

By analysing the figure 2, we can see that there are 3 types of elements: a NPN BJT, resistors and capacitors. The first capacitor, C_in , is a coupling capacitor, that acts as a DC Block, so that V_in doesn't introduce a DC component of 0, that would change the Operating Point (OP) of the transistor. The second capacitor, C_E , acts as a bypass capacitor, for it ensures that for low frequencies all the current flows through R_E, and for high frequencies, it passes through the capacitor. Generally, the output impedance of this stage is high, when compared with the load, being this the major reason why we cant use just this stage, and we need another one.

Both of the capacitors are being analysed in the section of Simulation Analysis.

2.1.1 Inspection analysis

2.1.2 Cutoff frequencies

2.2 Output stage

As we could see in the section of the Gain stage, we end up with a high output impedance Z_O1 . For that reason, we connect a second circuit to the output of the Gain Stage, that produce a low output impedance. This part of the stage is presented in the figure below:

By analysing the figure, we can conclude that this circuit presents similar components but with some differences. Instead of a NPN BJT, we use a PNP BJT, because it has a higher β_F, that lowers the output impedance as we desire. It also illustrates the use of another BJT transistor.

Another capacitor, C_o , is used with a similar goal as the previous coupling capacitor. If we didn't use this component, the gain stage would introduce a DC voltage of 0 to the second stage, which as previous would change and ruin the transistor's Operating Point.

We will end up with a lower output impedance in this stage, when compared to the load, and a higher input impedance when compared to the output impedance of the gain stage. When we combine both stages, we need to ensure that there is a compatibility between the impedances of both stages. In fact, by the voltage divider law, to make sure no voltage signal is lost, the input impedance of the second stage should be much greater than the output impedance of the first one.

To conclude, when we merge these two circuits, we end up with the BJT Audio Amplifier represented in Figure 1.

3 Simulation Analysis

In this section, Ngspice was used in order to simulate the audio converter, therefore, a brief description of the circuit modeled in NGspice is going to be presented and a comparison between the values obtained in NGspice and the ones in Octave is going to be done as well. In order to do that, transistors of the given models were used and the rest of the components specifications changed to be on par with the values through MatLab.

3.1 Coupling Capacitor

3.2 Bypass Capacitor

3.3 R_c

3.4 Comparison

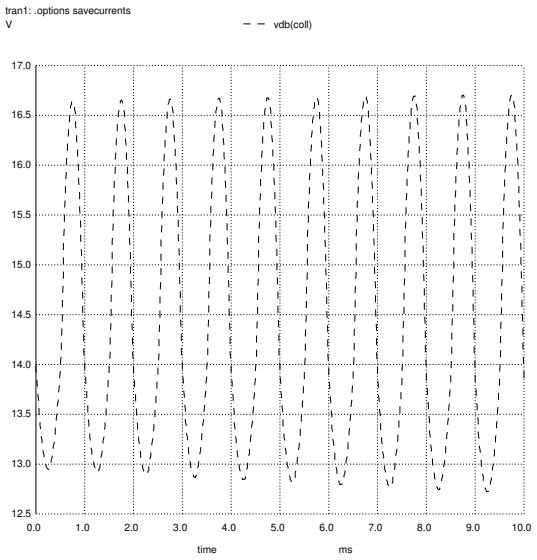

Figure 3: Output

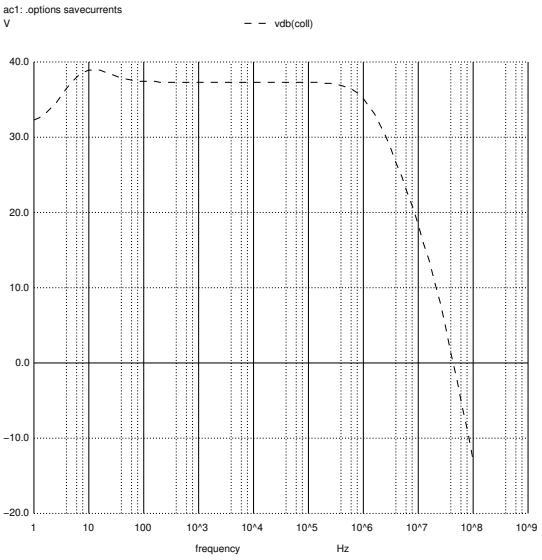

Figure 4: Output

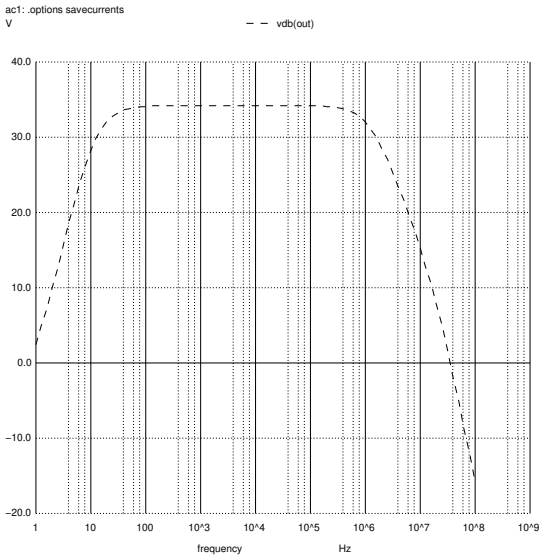

Figure 5: Output

3.5 Merit Results

From the results obtained through the Ngspice simulation and considering we used the data shown in table 1, we can compute the merit using the formula given in the lab assignment, represented in the Introduction.

The implemented circuit gave us a MERIT of ??? in NGSpice.

4 Conclusion

In this laboratory assignment, the goal especified in the introduction has been achieved with a great merit. All analyses have been performed both theoretically using the Octave maths tool and by circuit simulation using the Ngspice tool. When comparing these last two we conclude that there aren't any disparity between the results and therefore no errors associated. So, we conclude that the architeture that we used can be validated.