

Circuit Theory and Electronics Fundamentals

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Laboratory Four Report

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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 below.

$$Merit = \frac{VoltageGain * bandwidth}{Cost * CutoffFreq} \quad (1)$$

2 Simulation Analysis

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

Parameters	Values
vcc[0]	0.000000e+00,0.000000e+00
in[0]	1.000000e+00,0.000000e+00
in2[0]	9.462362e-01,-4.02794e-02
base[0]	8.821295e-01,4.528835e-02
coll[0]	-6.90782e+01,-4.06314e+01
emit[0]	3.972570e-01,-4.00299e-01
emit2[0]	-6.54598e+01,-2.85270e+01
out[0]	-1.03656e+01,-4.20939e+01

Table 1: 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.

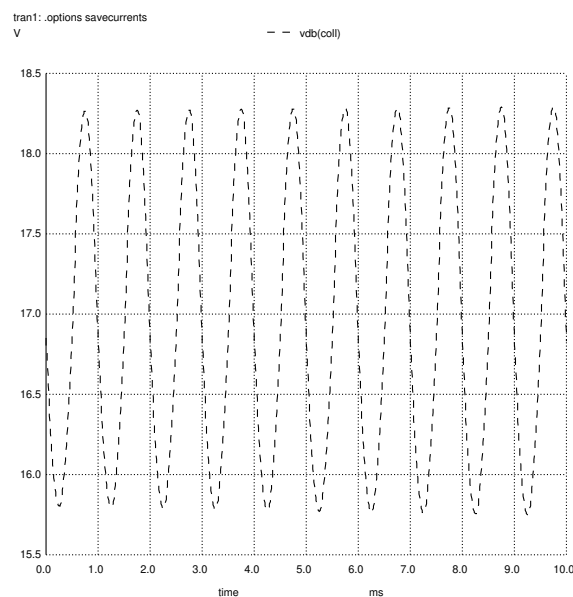


Figure 1: Voltage in the collector, transient analysis.

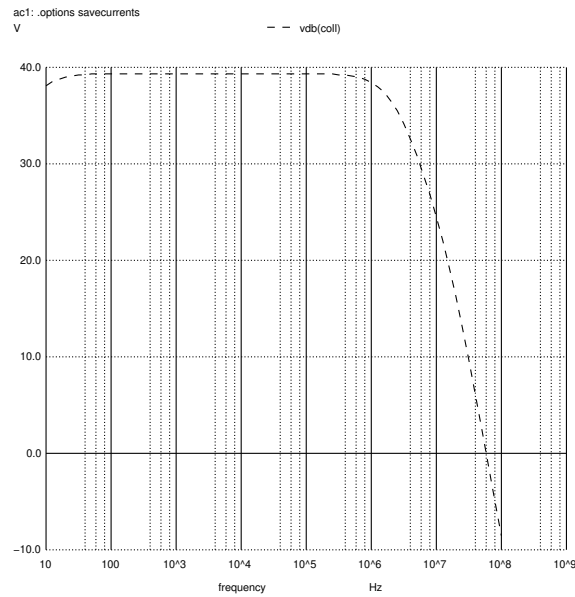


Figure 2: Voltage in the collector[dB], frequency analysis.

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.

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 2: Values computed in the simulation.

Parameters	Values
impedout	7.818064e+04

Table 3: Output impedance.

3 Theoretical Analysis

In this section, we used the theoretical 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.

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.

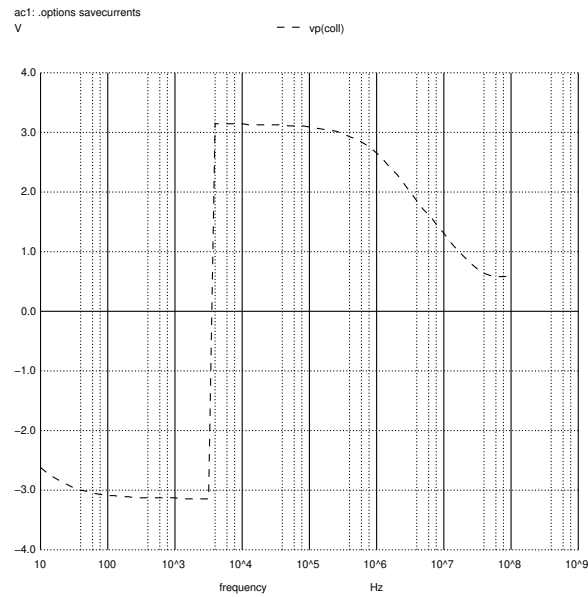


Figure 3: Phase voltage in the collector, frequency analysis.

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.

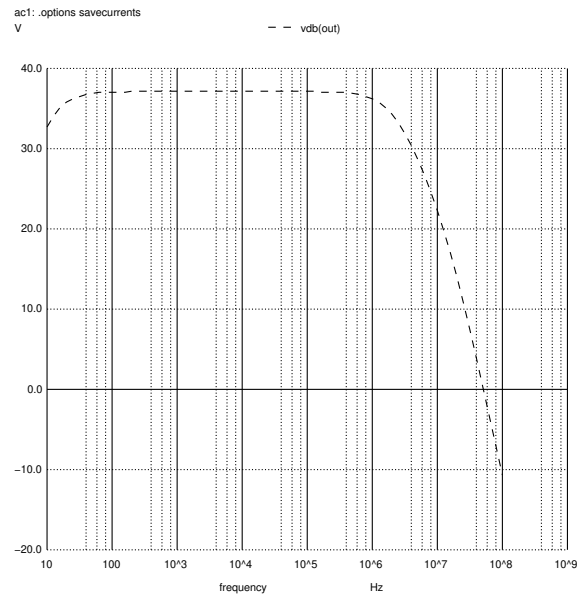


Figure 4: Output voltage[dB].

4 Conclusion

To sum up, in this assignment, the main goal was

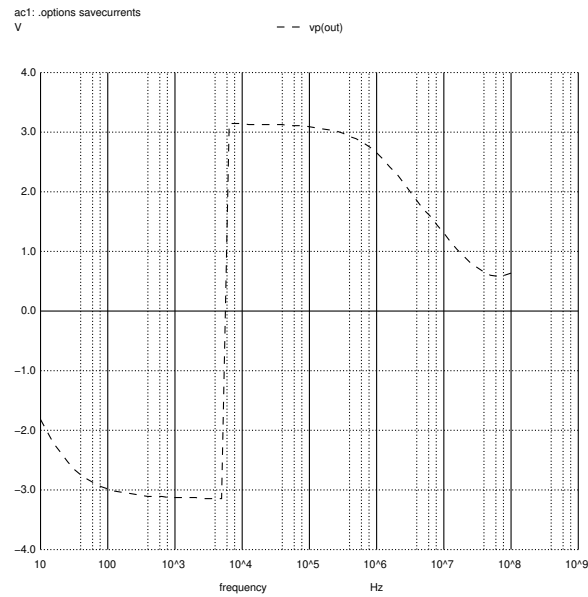


Figure 5: Output voltage phase.

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 4: Transistor's parameters.

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

Table 5: Parameters of slide 10, lecture 16.

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

Table 6: Gain and impedances.

Parameters	Values
V_{coll}	6.925864
V_{emit}	7.625864
V_{cc}	12.000000
I_{B2}	0.000087
I_{C2}	0.019795
I_{E2}	0.019882

Table 7: Parameter values for the output stage.

Parameters	Values
g_{m2}	0.791814
g_{o2}	0.000532
g_{pi2}	0.003484
g_{e2}	0.004545
Input Impedance	26837.230759
Output Impedance	1.249414
Gain	0.989304
Gain(dB)	-0.093408

Table 8: Output stage impedance and gain.

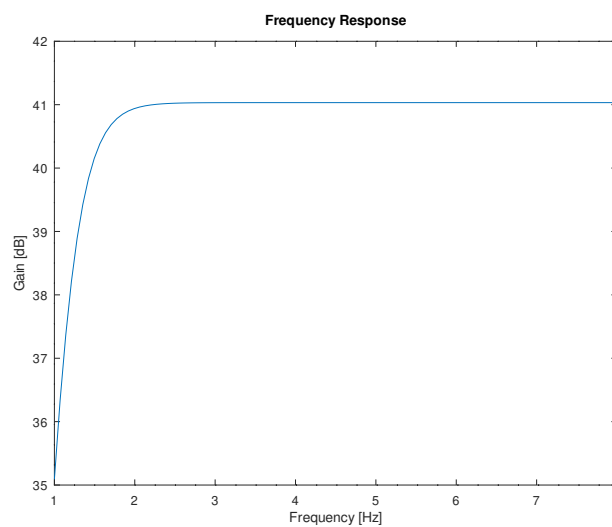


Figure 6: Plot of Gain in order of the Frequency (Hz).