TÉCNICO LISBOA

Circuit Theory and Electronics Fundamentals

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Audio Amplifier

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Contents

1 Introduction

The objective of this laboratory assignment is to build an audio amplifier

In Section **??**, a theoretical analysis of the circuit is presented. In Section **??**, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section **??**. The conclusions of this study are outlined in Section **??**.

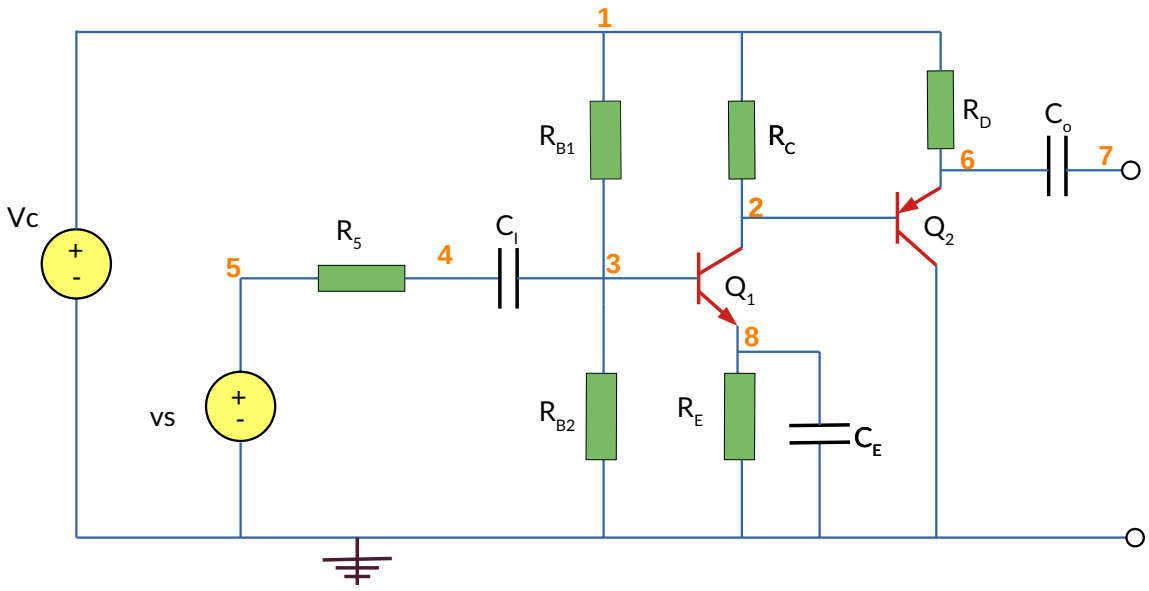


Figure 1: Audio Amplifier Circuit

2 Simulation Analysis

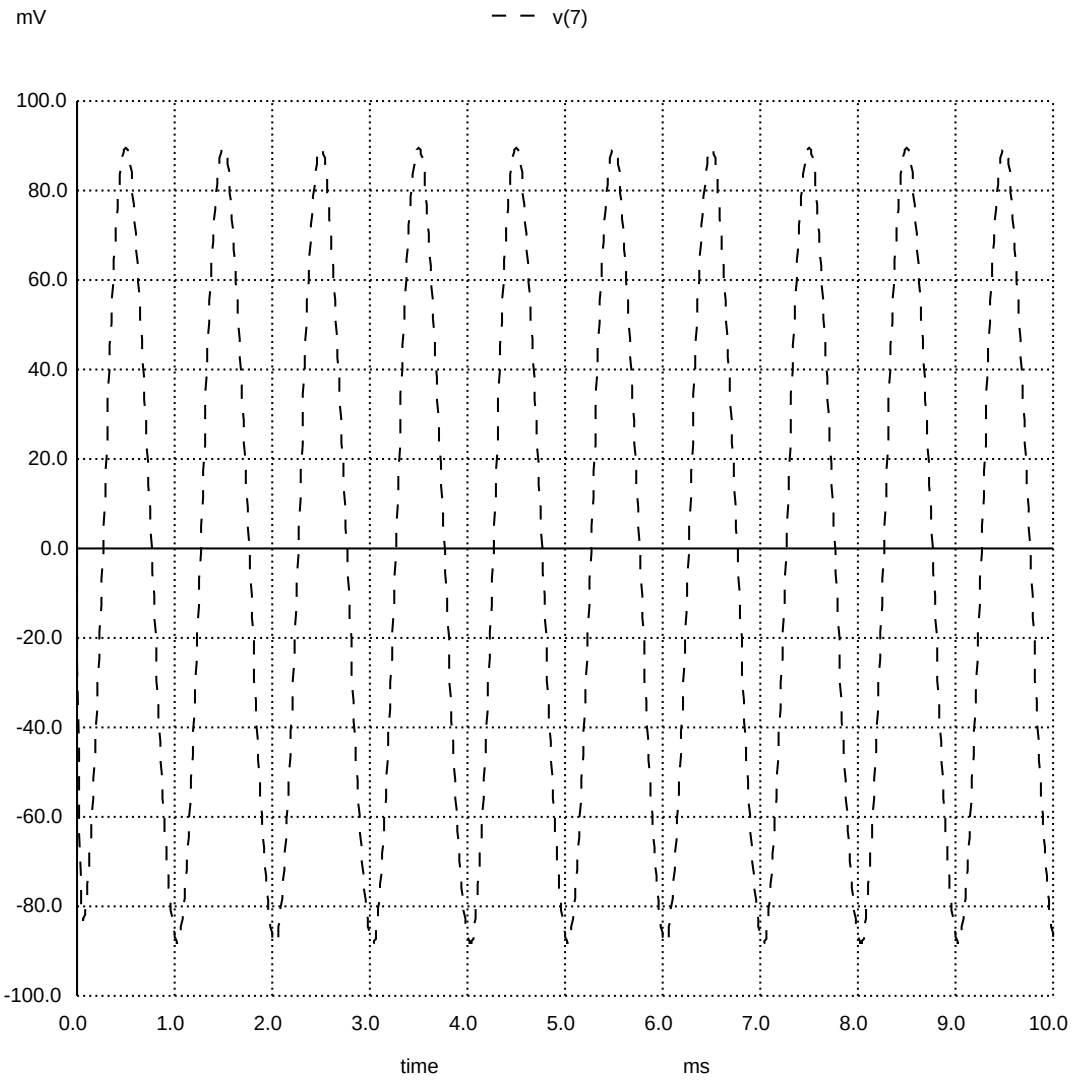
2.1 Transient analysis

We simulated the circuit using transient and frequency analysis, using the supplied model of transistors:

Table 1: Values of capacitances and resistances for various circuit components

Vc	12.0 V
Vs	10e-3 V
Rs	100
Ci	1e-3 F
Rb1	80e3
Rb2	20e3
Rc	1e3
Re	100
Ce	1e-3 F
Von	0.7 V
Vt	25e-3 V
Va1	69.7 V
Va2	37.2 V
Rd	100
Co	1e-6 F
Rl	8

Using transient analysis, and frequency f=1e3 Hz, we simulate the circuit, which yields the following $v_7(t)$:



We simulate the circuit using frequency analysis and max(vs(t))=1, obtaining the following gain in v_2, which is the gain after the gain stage:

And the gain in v_7,which is the gain after the output stage:

This circuit has a cost of , voltage gain 3.790425e+01, bandwidth 1.594837e+06, minimum voltage cuttoff 8.880395e+03 and the calculated Merit is

3 Theoretical Analysis

For the theoretical simulation, we used the dependent voltage source model of the transistors, with Bf1=178.7 and Bf2=227.3.

The bias circuit, which is constituted by V_c, R_{B1} and R_{B2}, will determine V_b.

To simplify the bias circuit, we can ignore the capacitors and make a Thevenin equivalent. This yields:

$$R_B = \frac{R_{B1}R_{B2}}{R_{B1} + R_{B2}} \tag{1}$$

$$V_{eq} = \frac{R_{B2}}{R_{B1} + R_{B2}}V_c \tag{2}$$

To calculate the current that passes through the node 8 we know that $I_E = (1 + \beta_f)I_B$

For the results of the OP analysis we obtain:

Table 2: Some values of the operating point analysis

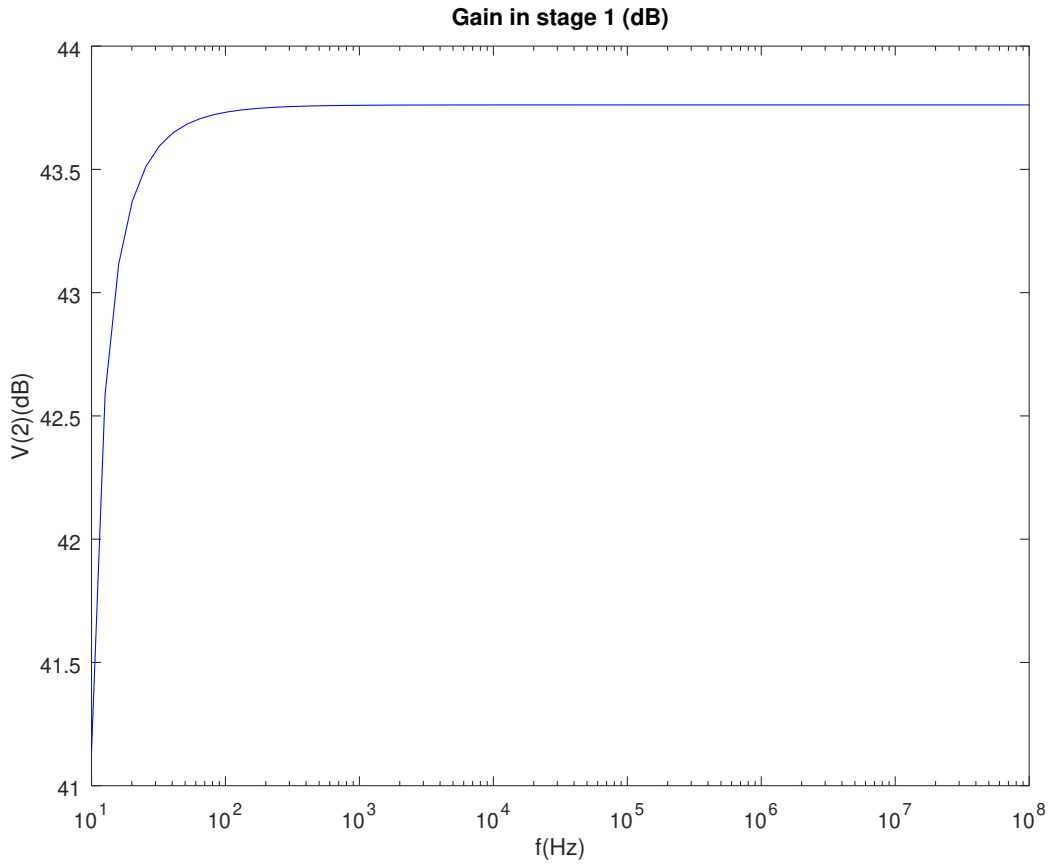
I_{b1}	5.0044e-05
I_{e1}	0.0089929
I_{c1}	0.0089429
V_{CE}	2.1578

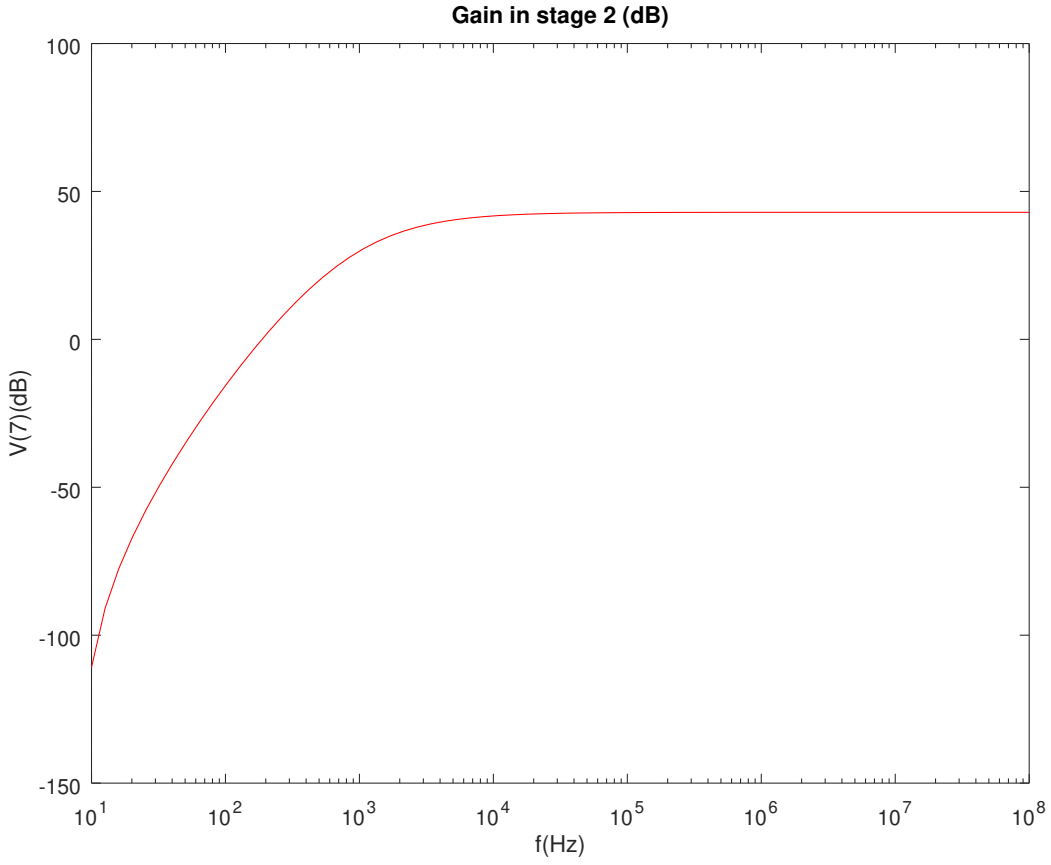
The incremental model of the transistor was used to calculate the input and output impedances, as well as the gain on both stages of the circuit. The capacitors were modelled as short circuits in this stage. This yields:

Table 3: Some values of the operating point analysis

Z_{i1}	484.43
Z_{o1}	886.28
Z_{i2}	8598.9
Z_{o2}	0.30217
$Gain_1$	-262.79
$Gain_2$	0.99195
$Gain_{Total}$	-260.67

Lastly, the capacitors were re-introduced in order to calculate the gain as a function of the frequency after each stage. The results are graphed below:


Gain in stage 1 (dB)
44
43.5
43
42.5
42
41.5
41
V(2)(dB)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
f(Hz)


Gain in stage 2 (dB)
100
50
0
-50
-100
-150
V(7)(dB)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
f(Hz)

The lower cut-off point is at $f = 5484.4Hz$ As we can see, the lower cut-off point is accurrate, but this model does not deal well with the higher cut-off point.

4 Conclusion

In this laboratory assignment the objective of building an audio amplifier was achieved. The cost of the circuit was of MU.

The results from both the theoretical analysis using octave and the circuit simulation using ngspice appear to match, as we can see in the following table:

Table 4: Values of gain and input and output impedance for theoretical and simulation analysis

	Mat	Sim
Zi1	484.43	563.83
Zo1	886.28	-
Zi2	8598.9	-
Zo2	0.30217	10.07
Gain1	262.79	-
Gain2	0.99195	-
- GainT	260.67	37.904 dB
LowCOP	-	8.88k
BdWth	-	1.60M
Cost	-	-

The differences of both methods of analysis can be attributed to the various aproximations made in the theoretical analysis, where as the simulation uses the comparatively accurate spice model.