T4 - Audio Amplifier

Integrated Master in Physics Engineering

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1 Introduction

In this laboratory assignment we seek to build an audio amplifier circuit , with the goal of maximizing the merit figure, M, given by:

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

being that the voltage gain is given by the quotient between the output voltage and the input voltage; the bandwidth is the magnitude of the interval of frequencies for which the circuit functions; and the lower cut off frequency is given by the lowest frequency for which the circuit functions. The cost equals the sum of the cost of each individual component.

The circuit consists only of resistors, voltage sources (AC as well as DC), capacitors and bipolar junction transistors (more specifically one PNP transistor and one NPN transistor)

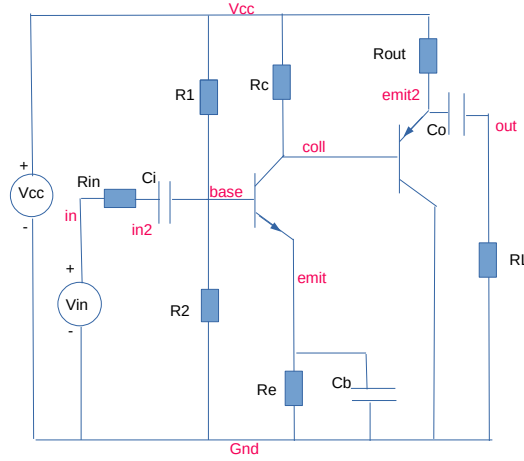The circuit used was the following:

Figure 1: Circuito utilizado

In Section 2, a theoretical analysis 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

2.1 First part

The theoretical analysis is split into three parts. In the first part we compute the operating point using the Ebers-Moll model for the transistor. Taking into account the fact that capacitors act as an open circuit on the operating point, and using Thevenin's theorem to simplify the circuit, we get the following equations:

$$R_{th} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

$$V_{th} = \frac{R_2 V_{CC}}{R_1 + R_2}$$

$$I_{B1} = \frac{V_{th} - V_{BEON}}{R_{th} + (1 + \beta_{FN})R_e}$$

$$I_{C1} = \beta_{FN} I_{B1}$$

$$I_{E1} = (1 + \beta_{FN})I_{B1}$$

$$V_{E1} = R_e * I_{E1}$$

$$V_{O1} = V_{CC} - R_1 I_{C1}$$

$$V_{CE} = V_{O1} - V_{E1}$$

being that I_{B1} is the current going **into** the base of the first transitor; I_{E1} is the current going **out** of the emitter of the first transistor; V_{O1} is the voltage at the 'coll' node; $V_C E$ is the potential difference between the collector and emitter of the first transistor.

Using the following values:

RE1	100.000000
RC1	1000.000000
RB1	80000.000000
RB2	20000.000000
VCC	12.000000
RS	100.000000

Table 1: Values used as parameters for the circuit studied.

We get:

IB1	0.000050
IC1	0.008943
IE1	0.008993
VE1	0.899293
VO1	3.057109
VCE	2.157816
gm1	0.357716
rpi1	499.558824
ro1	7793.900392
ZI1	484.433630
ZO1	886.284816
AV1	262.790895
VI2	3.057109
IE2	0.082429
IC2	0.082068
VO2	3.757109
gm2	3.282714
go2	0.002206
gpi2	0.014442
ge2	0.010000
AV2	0.991948
ZI2	8598.855359
ZO2	0.302173
a	0.828894
b	0.906561
c	0.963603

Table 2: Values used as parameters for the circuit studied.

2.2 Second part

In this part we compute the gain, input and output impedances separately for the 2 stages. The model used for the transistors here is the same.
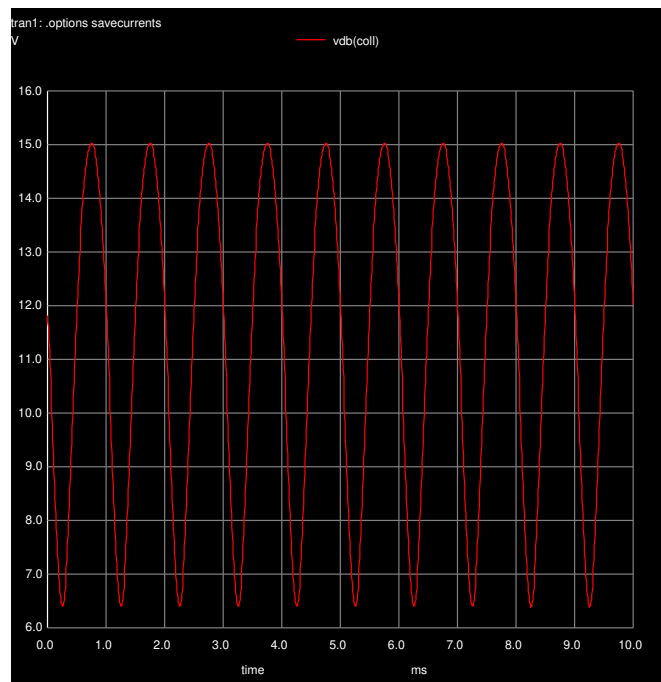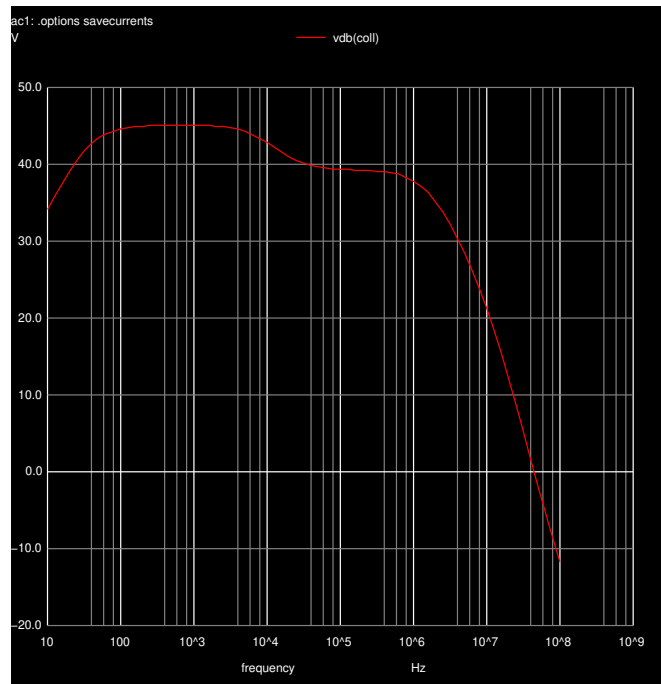
3 Simulation Analysis
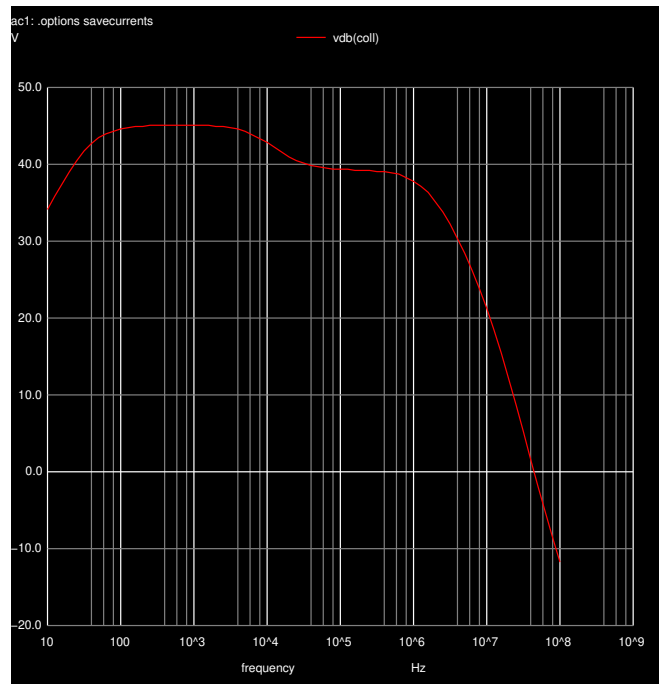

Figure 2: ———

Figure 3: ———————

Figure 4: —————

4 Conclusion

In this laboratory assignment the objective of analysing a simple circuit has been achieved.