Circuit Theory and Electronics Fundamentals

Masters of Aeroespace Engineer, Técnico, University of Lisbon

Laboratory Report

Group 37

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Contents

1 Introduction

The objective of this laboratory assignment is to choose the best architecture of the circuit in order to build a Bandpass filter using OP AMP. This assignment allowed us to deal with important concepts such as OP AMP 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:

$$M = \frac{1}{cost * (gaindeviation * centralfrequencydeviation + 1e - 6} \quad (1)$$

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 transistors = 0.1 MU per transistor

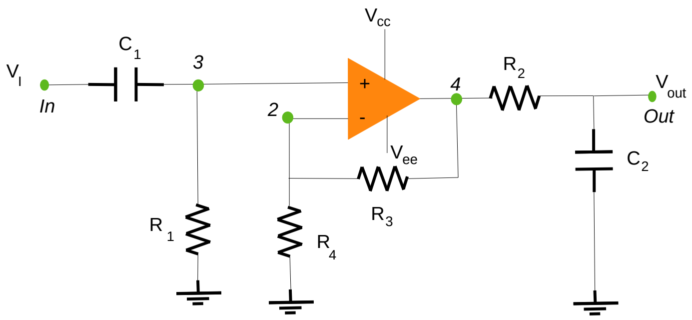


Figure 1: Main circuit

The constants values used are expressed in the following table.

Name - Value	
C1	2.200000e-07
C2	1.100000e-07
R1	1.000000e+03
R2	1.000000e+03
R3	1.000000e+05
R4	1.000000e+03
Vcc	1.000000e+01

Table 1: Inicial Values

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 bandpass filter using OP AMP.
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.

2.1 Transfer function computation

Name - Value	
LowFreq BandPass	4.545455e+03
HighFreq BandPass	9.090909e+03
Central Freq	6.428243e+03

Table 2: BANDPASS FREQUENCY

Name - Value	
Central Freq (Hz)	1.023087e+03
Gain Central Freq (dB)	3.656460e+01

Table 3: WO FREQUENCY GAIN

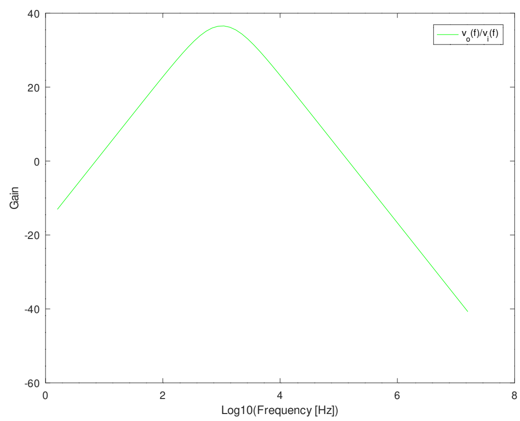


Figure 2: Gain

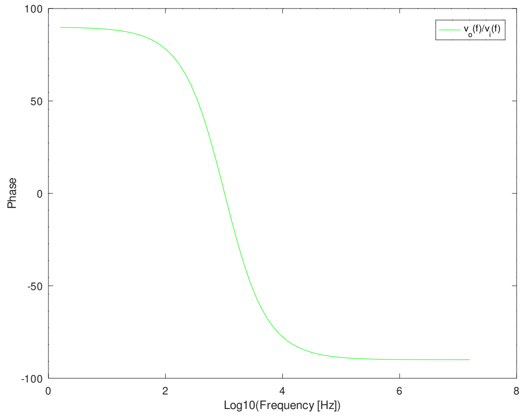


Figure 3: Phase

2.2 Input and Output Impedances

Name - Value	
Z in	1.000000e+03 + -7.071068e+02j
Z out	6.666667e+02 + -4.714045e+02j

Table 4: IMPEDANCES

In this section, a theoretical analysis of the circuit shown in section 1 was conducted. The OP Amp was considered ideal (internal impedance between v+ and v- is infinite, which means no current flows through it and vos=0 or in other words v+ = v-). So, in order to build a bass pand filter, a capactior was connected in series (C1) with the input voltage which will function as a high pass filter (for low frequencies, the impedance goes to infinity and the capacitor is basically an open circuit) and other capacitor (C2) was connected in parallel with the output voltage, functioning as a low pass filter (for high impedances, the impedance goes to 0 and the capacitor is basically a short circuit). To sum up, this circuit consists of a high pass filter, a signal amplifier and a low pass filter in series.

3 Simulation Analysis

In this section, Ngspice was used in order to simulate the Bandpass Filter. 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, OP AMP of the given models were used and the rest of the components specifications changed to be on par with the values through MatLab.

In the next sections we are interested in ... . The measurement of these parameters and the overall performance of the circuit is represented in the beggining of the 3.3.

3.1 Circuit simulation

Name - Value	
Gain	36.5323
Central Frequency	1000
Gain deviation	32.9164
Central frequency deviation	0

Table 5: Results

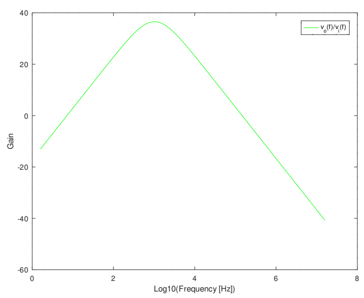
3.2 Input and Output Impedances

Name - Value	
Zin	999.002 + -7.3282 j

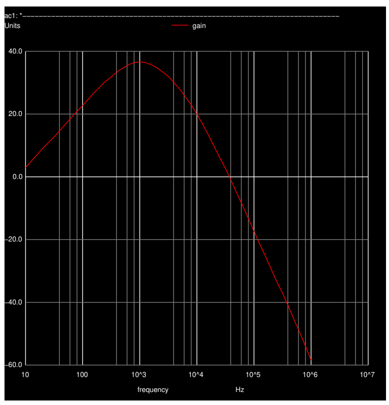
Table 6: Zin

Name - Value	
Zo	0.0522978 + -7.23396 j

Table 7: Zout

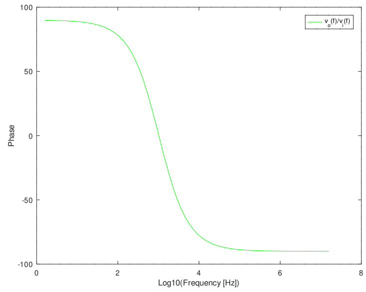


(a) OCTAVE

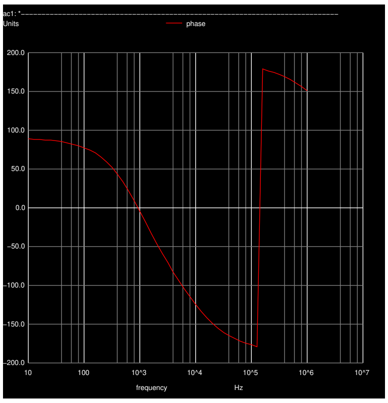


(b) NGSPICE

Figure 4: Gain



(a) OCTAVE



(b) NGSPICE

Figure 5: vo1f

3.3 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 values of cost and merit are represented in the next table:

Name - Value	
Cost	2.639850e+02
Merit	1.428277e-04

Table 8: Octave

Name - Value	
Cost	263.985
Merit	0.000115082

Table 9: NGspice

Table 10: Cost and Merit

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

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.