Audio Amplifier

Computer aided design project

Student **Coordinating professor**

Pop Razvan – Valentin **Fizesan Raul**

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1. Circuit Description

The aim of the project is to design and implement an audio amplifier which has the amplitude of the input signal equal to 300µV and the output will be in the (2V, 5V) interval. The output resistance (speaker) is 25Ω. As for the bandwidth, its values are in the (8192Hz,16384 Hz).

The circuit has four parts:

- INPUT
  - **Sine wave of amplitude of 300µV**.
- Filtering
  - Done with an active bandpass filter .
- Amplifiers , with 2 OpAmps (300µV -> 2-5V)
  - 3 stages of amplification and a voltage follower and power amplifier
- OUTPUT
  - Modifiable between 2V and 5V using the potentiometer (acting as a volume knob).

2. Circuit & Block diagram

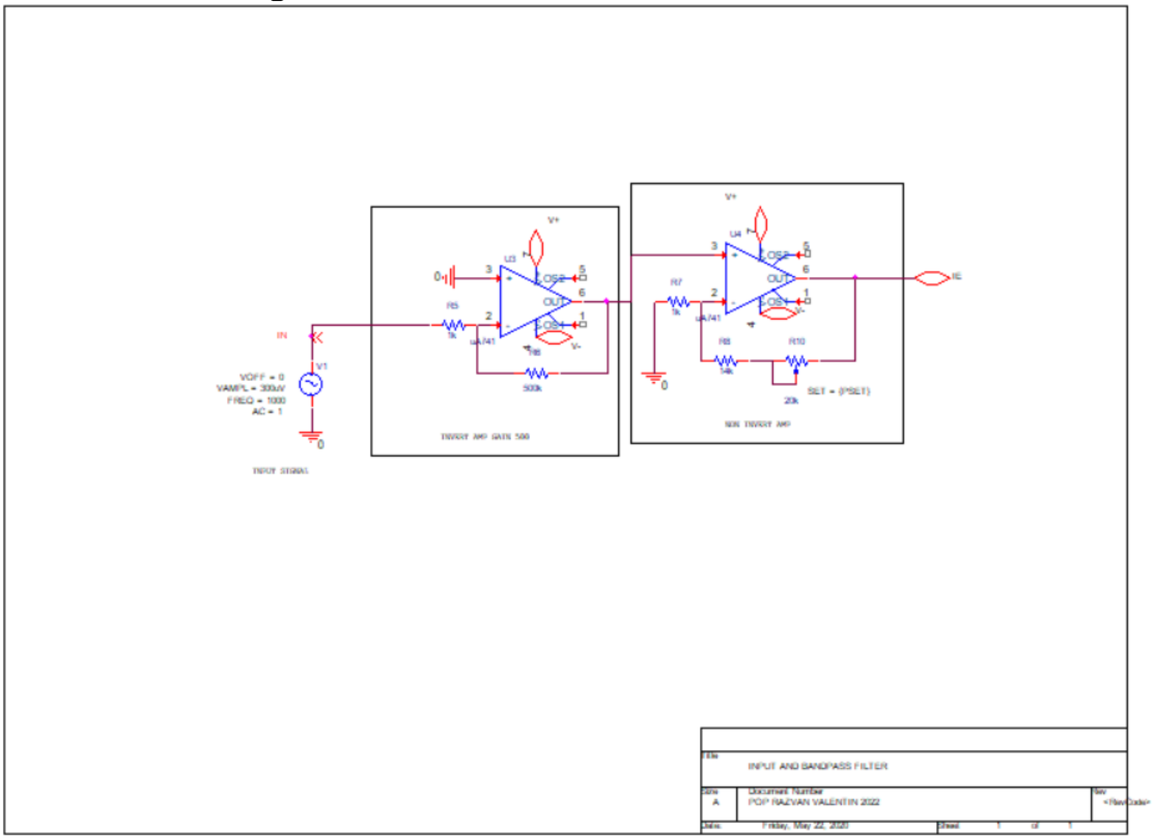


Figure 1 INPUT AMPLIFICATION

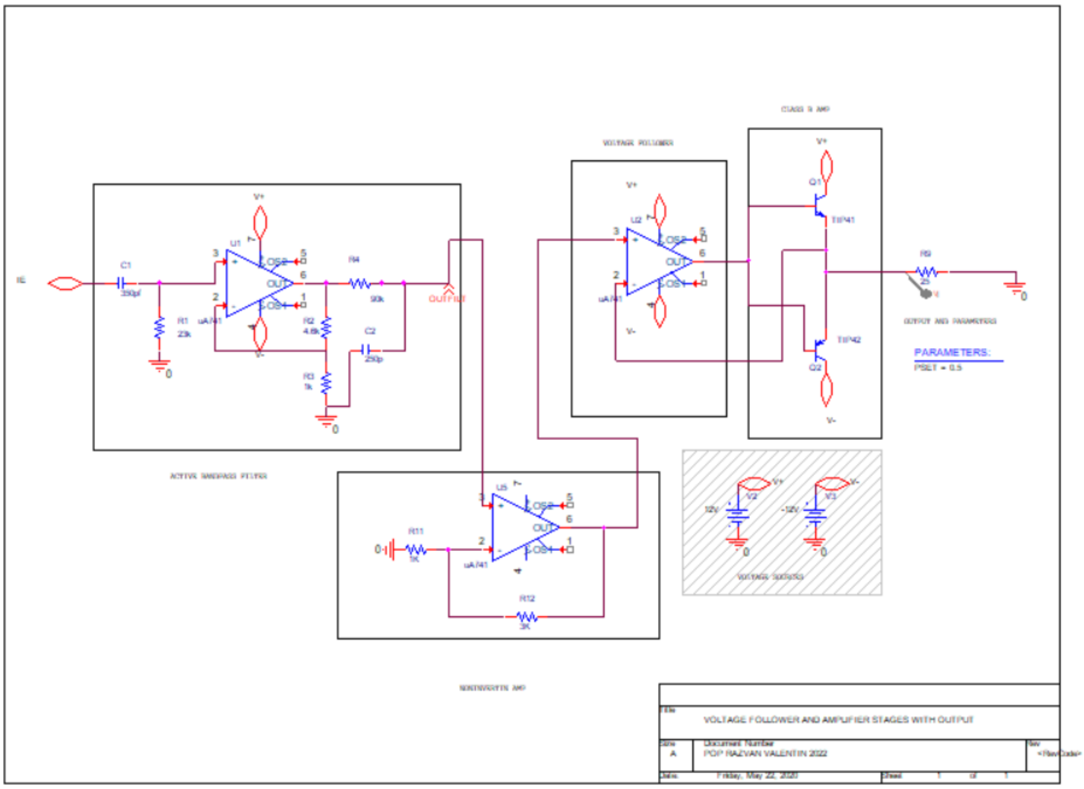
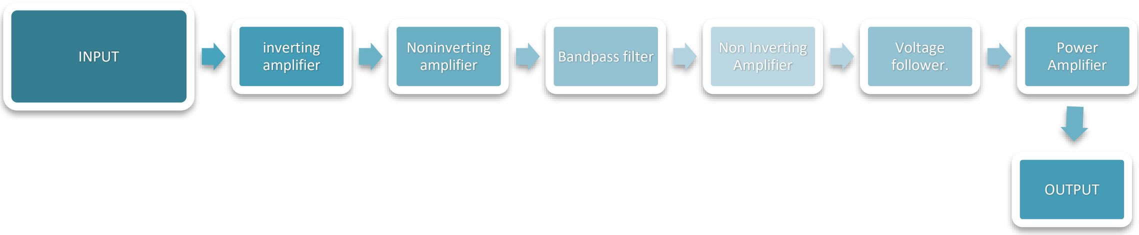


Figure 2 VOLTAGE FOLLOWER AT OUTPUT WITH BANDPASS FILTER



3.Components and formulas used :

3.1 Bandpass filter

The first computations for the cut-off frequencies were done using the formula :

$$fc = \frac{1}{2\pi RC}$$

So for the selected frequencies (8192 & 16384 Hz) , the values chosen at the start, for the capacitors were : 350pF and 250pF coupled with a 27.7k Resistor , respectively with a 77.7k one , and rechecked with the filters calculators found at [1] [2] , after that the filters were incorporated in a bandpass filter that cand be found at [3].

$$fc = \frac{1}{2 * \pi * 350pf * 27.7k} = 16424\ Hz$$

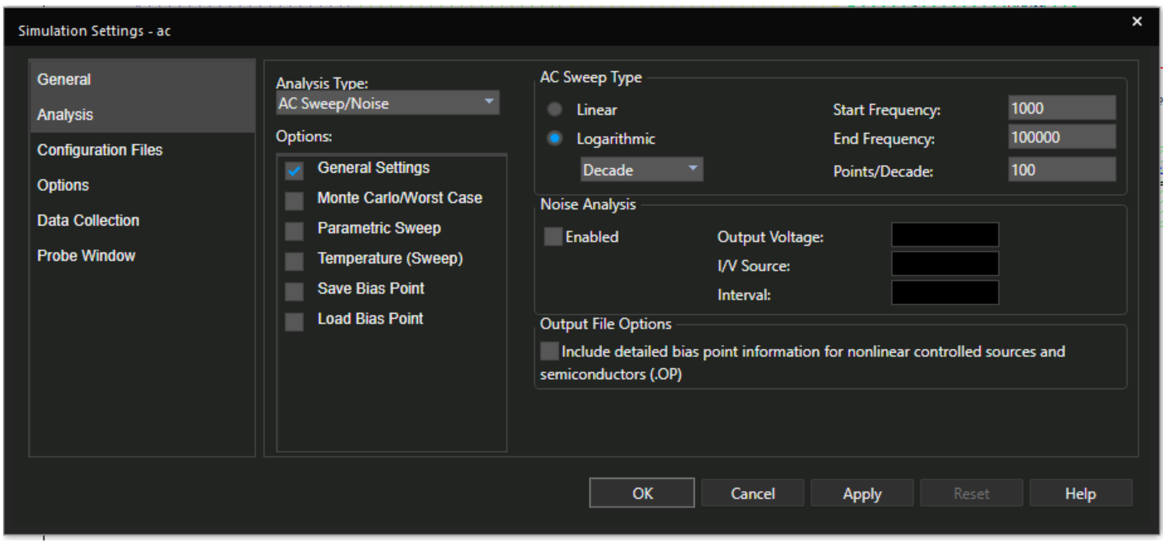
$$fc = \frac{1}{2 * \pi * 250pf * 77.7k} = 8197\ Hz$$

But after implementing the circuit with the other (uA741) parts I decided to go with the following resistance values : 23k(with 350pf capacitor) and 90k(with 250pf capacitor).Obtaining a very close bandwidth to the initial one 8562 – 16087 hz (that can be observed in the figure below):

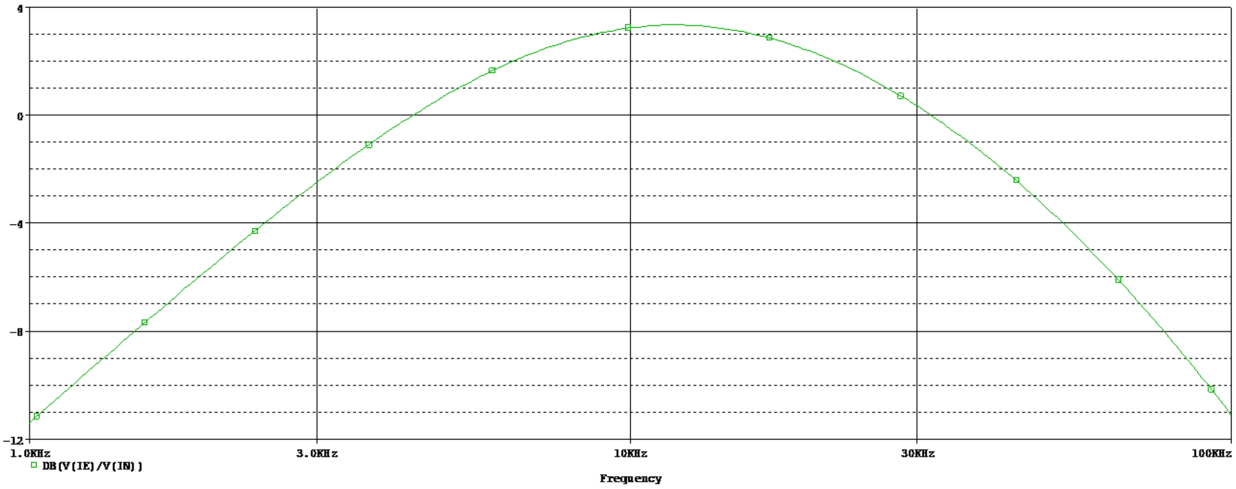
So far the total gain is 5.6 – obtained from the active bandpass filter , using the formula from the point [3] :

$$GAIN = 1 + \frac{R4}{R3} = 1 + \frac{4.6}{1} = \mathbf{5.6}$$

The bandpass filter was measured using the below simulation profile , an AC SWEEP that is between 1kHz and 100kHz.

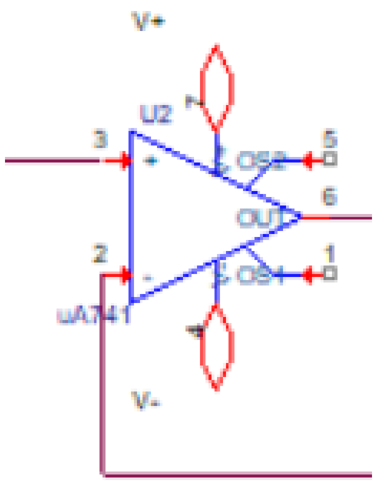


SIMULATION PROFILE 1 SETTINGS FOR BANDWITH



Results 1 Bandwidth of bandpass filter show in DB(V(IE)/V(IN)) in ***ORCAD***

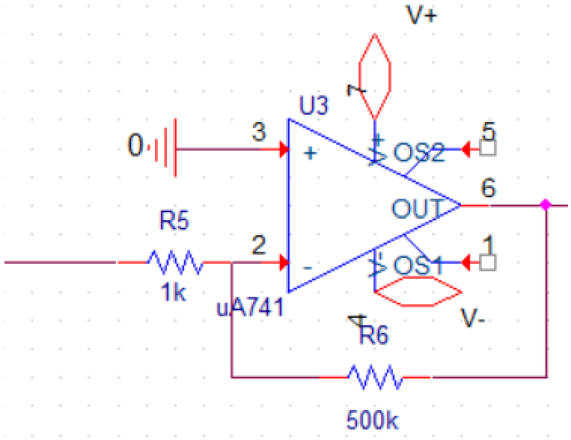
3.2 Voltage follower



COMPONENT 1 Voltage follower

The voltage follower implemented in the circuit is a simple one that has the base in the [4] point from bibliography and it consists in a operational amplifier 741 wired specifically.

3.3 Inverting amplifier



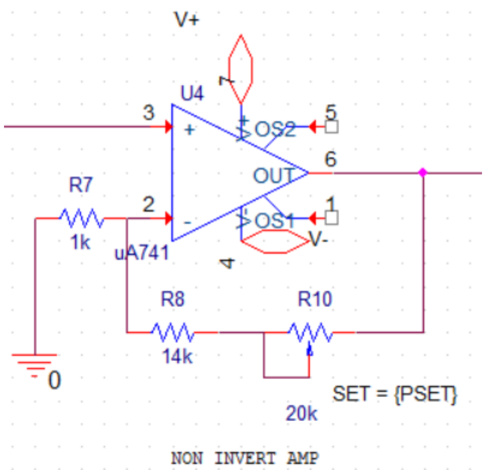
COMPONENT 2 Inverting amplifier

Because I used an active bandpass filter with the 741 operational amplifier , the output is in the negative domain , so I used an inverting amplifier with the gain computed below:

$$GAIN = -\frac{R6}{R5} = \mathbf{-500}$$

The schematic of the implemented inverting amplifier can be found at point [6] in bibliography , where can also be found the computation formula of the gain.

3.4 Non-inverting amplifier



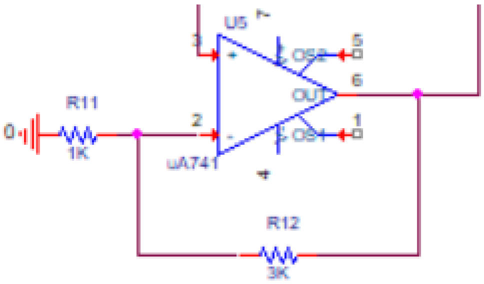
COMPONENT 3 Non-inverting amplifier

Because I now have obtained a positive domain signal , it is more facile to use a non-inverting amplifier that has the gain formula[5] shown below in pair with a potentiometer to adjust the output :

$$GAIN\ MIN = 1 + \frac{R8 + POTENTIOMETER}{R7} = 1 + \frac{14 + 0}{1.3} \cong \mathbf{12}\boldsymbol{MIN\ GAIN}$$

$$GAIN\ MAX = 1 + \frac{R8+POTENTIOMETER}{R7} = 1 + \frac{14+20}{1.3} \cong \mathbf{27}\ \boldsymbol{MAX\ GAIN}$$

3.5 Non-inverting amplifier

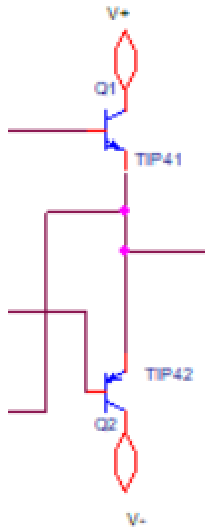


COMPONENT 4 NON INVER AMP

$$GAIN\ MIN = 1 + \frac{R12}{R11} = 4$$

After this last stage of amplification the signal is in the gave region of operation 2-5V.

3.6 Class B power amplifier



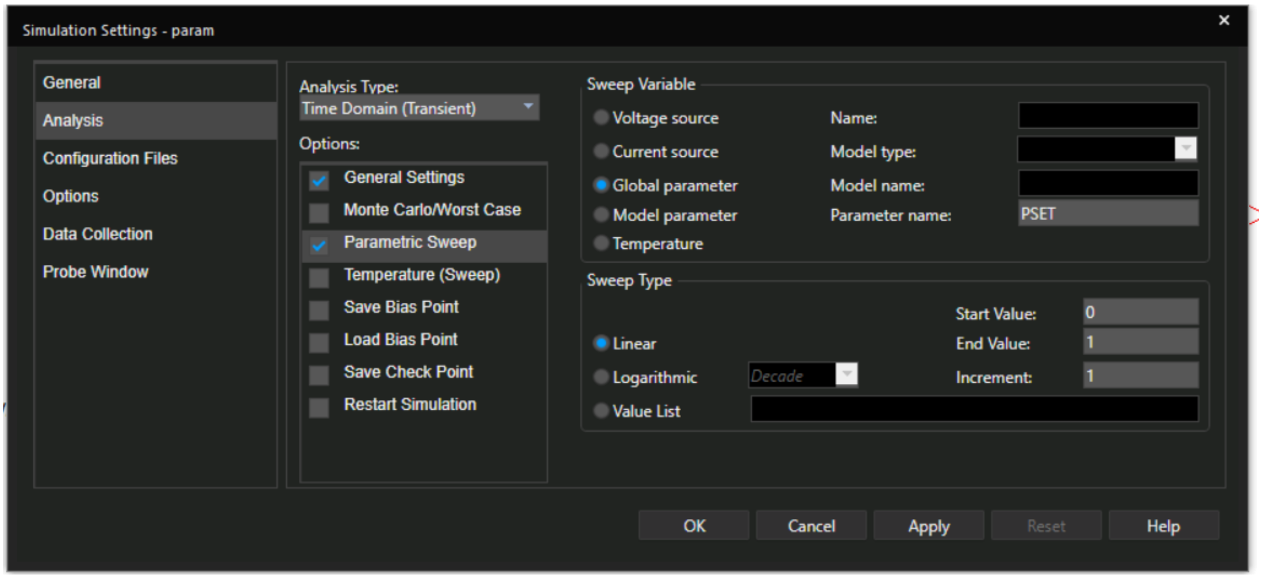
COMPONENT 4 CLASS B Power amplifier

I used a power amplifier of class B because of its response at the given frequencies , being known that they are ineffective at lower frequencies , and they dissipate less heat than the class A amplifier.[8]

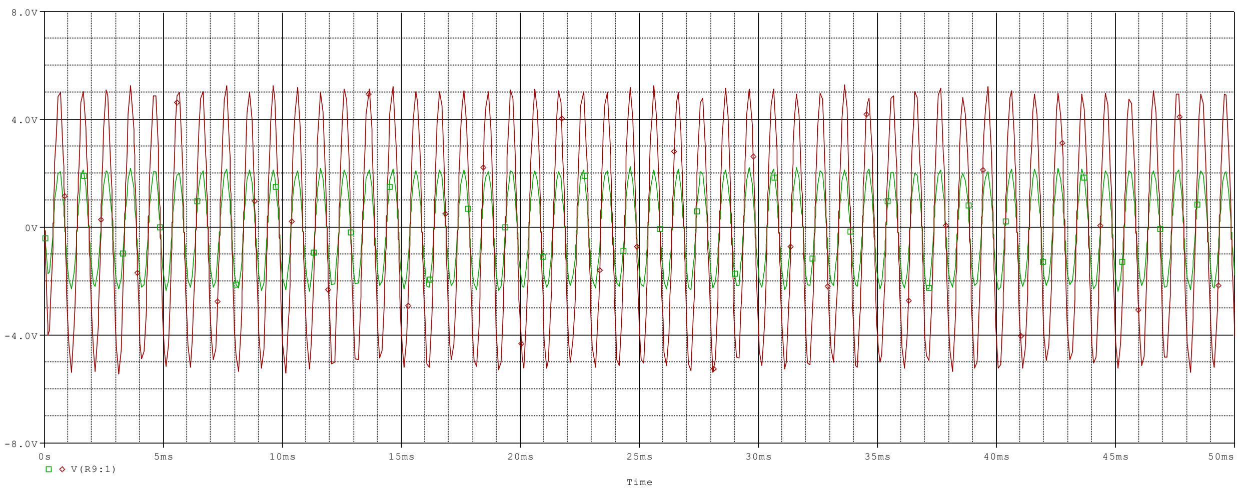
3.7 Output

At the output is present a 25ohm resistor as given in the prerequisite.

The voltage and current are measured using a parametric sweep with the below simulation profile , that sweeps the value of the parameter PSET , that gives the gain computed at point **3.4**.



SIMULATION PROFILE 2 FOR DETERMINING OUTPUT VALUES



*Results 2 Parametric sweep in **ORCAD** to show output voltage*

4.Standardization :

Table 1 Standard values

Nr.	Name	Value in initial schematic	Value after standardization	Found at:
1	uA741	-	-	here
2	500k Resistor	500000 Ω	-	here
3	23k Resistor	230000 Ω	-	here
4	14k Resistor	14000 Ω	-	here
5	TIP42	-	TIP42C	here
6	20 kΩ Pot.	200 Ω	20000	here
7	12K Resistor	12000 Ω	12000 Ω	here
8	3k Resistor	4600 Ω	3000 Ω	here
9	1k Resistor	1000 Ω	-	here
10	90k Resistor	77000 Ω	90900 Ω	here
11	250pF Capacitor	-	250pF	here
12	350pF Capacitor	-	350Pf	here

13	TIP41	-	TIP41C	here

5.Tolerances :

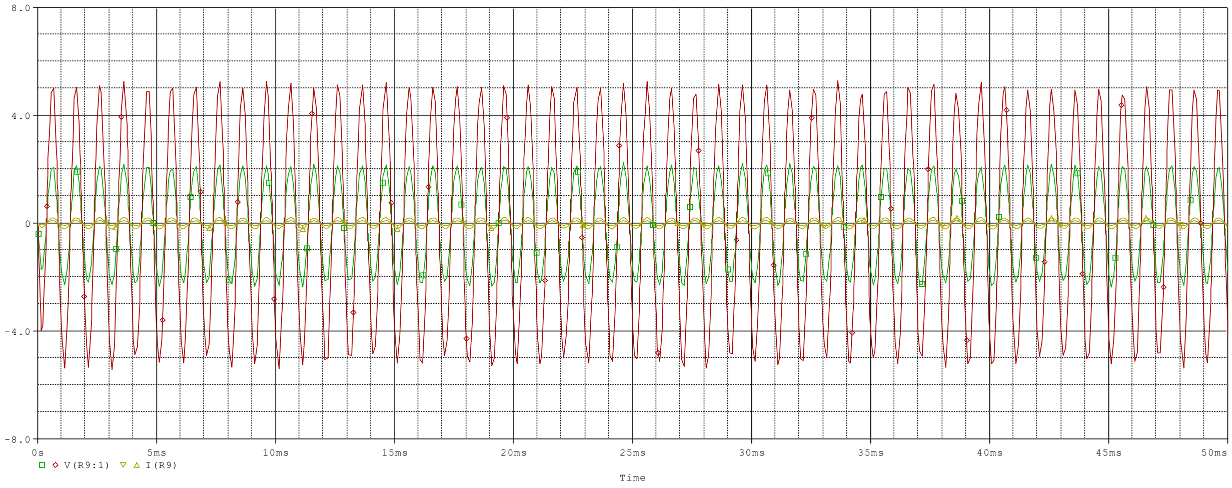
In this point I present the output results using the given simulations , but now the tolerances to every component are added after the documentation found at the given links in **Standardization** .

Table 2 Tolerances

Nr	Name	Tolerance
1	500K Resistor	5%
2	23K Resistor	0.5%
3	14K Resistor	1%
4	20K Potentiometer	20%
5	3K Resistor	1%
6	1K Resistor	5%
7	90K Resistor	0.1%
8	250pF Cap	10%
9	350pF Cap	5%

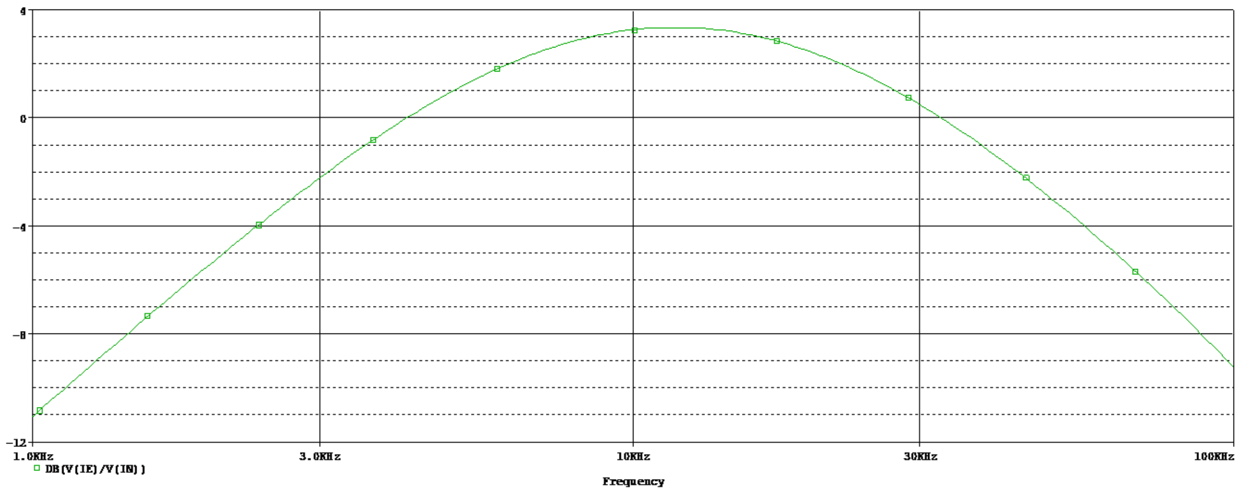
10	12K Resistor	5%

The results of the simulations in the time domain :



Results 3 Voltage at output

The results of the ac sweep to inspect the filtering capabilities of the filter setup:



Results 4 The filter response

6.Bill Of Materials(BOM):

Table 3 BOM

Nr	Name	Manufacturer
1	350pF Capacitor	Cornell Dubilier
2	23K Resistor	Vishay
3	3K Resistor	Stackpole
4	1K Resistor	Stackpole Electronics
5	90k Resistor	TT Electronics
6	12k Resistor	E-Projects
7	UA741 OPAMP	STMicroelectronics
8	500k Resistor	Vishay
9	20K Potentiometer	NTE
10	250pF Capacitor	Vishay
11	14K Resistor	Vishay
12	TIP42 PNP	Generics

13	TIP41 NPN	Uxcell

7.Conclusion:

I think this project helped me understand more about the structure of an electronic project and what goes behind translating it into real world.I learned that a big impediment is that the values need to be standardized , and that can really change the outcome of the circuit.

Bibliography

[1] http://www.learningaboutelectronics.com/Articles/Low-pass-filter-calculator.php#answer1
[2] http://www.learningaboutelectronics.com/Articles/High-pass-filter-calculator.php#answer1
[3] http://www.learningaboutelectronics.com/Articles/Bandpass-filter-calculator.php
[4] https://www.electrical4u.com/voltage-follower/
[5] https://www.electronics-tutorials.ws/opamp/opamp_3.html
[6] https://www.electronics-tutorials.ws/opamp/opamp_2.html
[7] http://www.learningaboutelectronics.com/Articles/Bandpass-filter-calculator.php#answer3
[8] https://www.watelectronics.com/power-amplifier-circuit-diagram-types-and-applications/