BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Electrical and Electronic Engineering

Course No: EEE 208 (Software)

Course Title: Electronic Circuits II Laboratory

Project Name—

Active Noise Cancellation

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Group 7

Section C2

Level 2, Term 2

Introduction

To listen to something attentively, we all want a quiet place. But in this modern age, it is rare to find such kind of place. But if anyone eliminates the noise from the environment while listening, then he or she can listen properly. In this project, our objective is to reduce the noise. When we input any music or anything else, noise is easily mixed with it. Our project can lessen the noise from the audio file to a great extent. Here we have built a simple op-amp-based circuit. Our main theme was the superposition of two waves. By this, we just inverted noise with proper magnitude and shifting and almost reached our desired output by superimposing it with the main audio input file.

Working Principle

Sounds-canceling headphones work primarily by mounting a microphone on the outside of the headphones, which gathers up ambient noise. Then these noise sounds are amplified according to the magnitude of the inverted noise got from the main music input which is unwanted. After this, the amplified noise is shifted lightly. At the main music input port, the music along with the noises are inverted. Further, when the two are summed up, the desired noise-free output (music, voice/speech) will come properly. Here, this project is mainly op-amp based. And the operations (amplification, delay, invert, sum) are done by opamp UA741.

Block Diagram

We have designed our project through 3 phases: a pre-amplifier, a delay, and an inverting summer. Here the noise we do not want is taken additionally by the external microphone. There is likely a tiny hole in the external casing of each earpiece. These are the microphones that are the input at the far left of the diagram below.

Then comes Pre-amplifier. The noise wave is then amplified with an increment in amplitude. For this operation, we have used op-amp as the gain factor in it can be determined by the ratio of the two resistors we take.

The delay filter delays the signal according to the distance from the ear to the microphone. We know there is a velocity difference between light and sound signals. So the time period difference after pre-amplifying and the output of the bottom summer is not negligible. The bottom inverting summer is in the main input of headphones where along with the music/speech, unwanted noises from the environment are mixed to the ear. This happens with the speed of sound. But noise through the external microphone and the rest of the circuit is an electric signal. So to lessen the time gap, the delay works to line up the two signals.

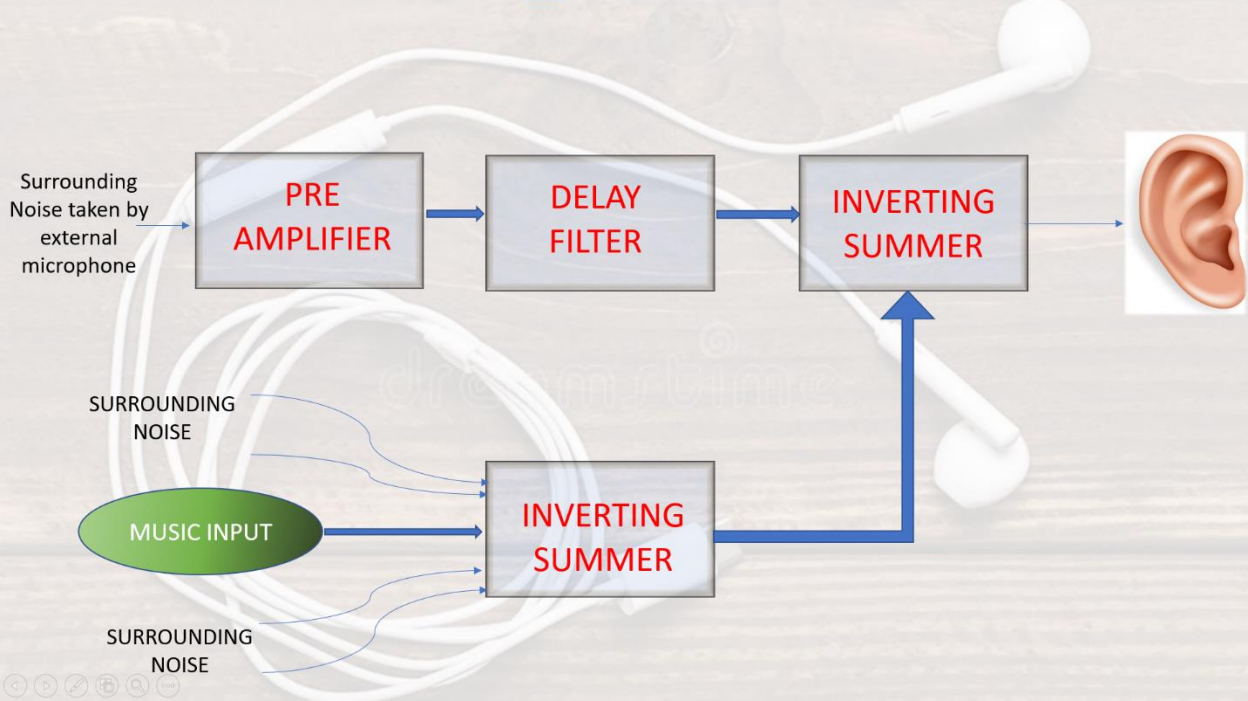
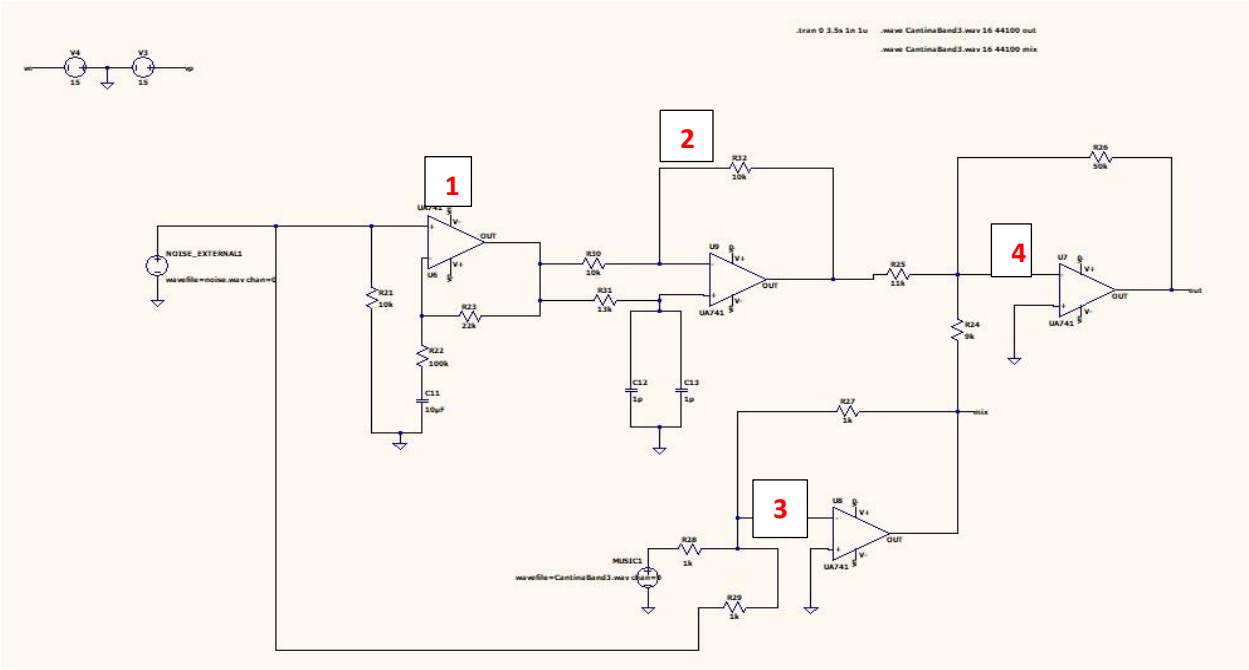


Fig: Block Diagram of the circuit

Lastly, the summing amplifier combines the signals. The amplifier at the bottom is just next to the main input of air or headphones. Here the music or speech we listen to is amplified. Also, the surrounding noise comes to our ears through the earbuds. This noise will also be inverted and amplified by this summer. The summer at the top is the final stage. This stage combines the inverted noisy music with the processed noise signal, cancels the noise, and then inverts the resultant wave.

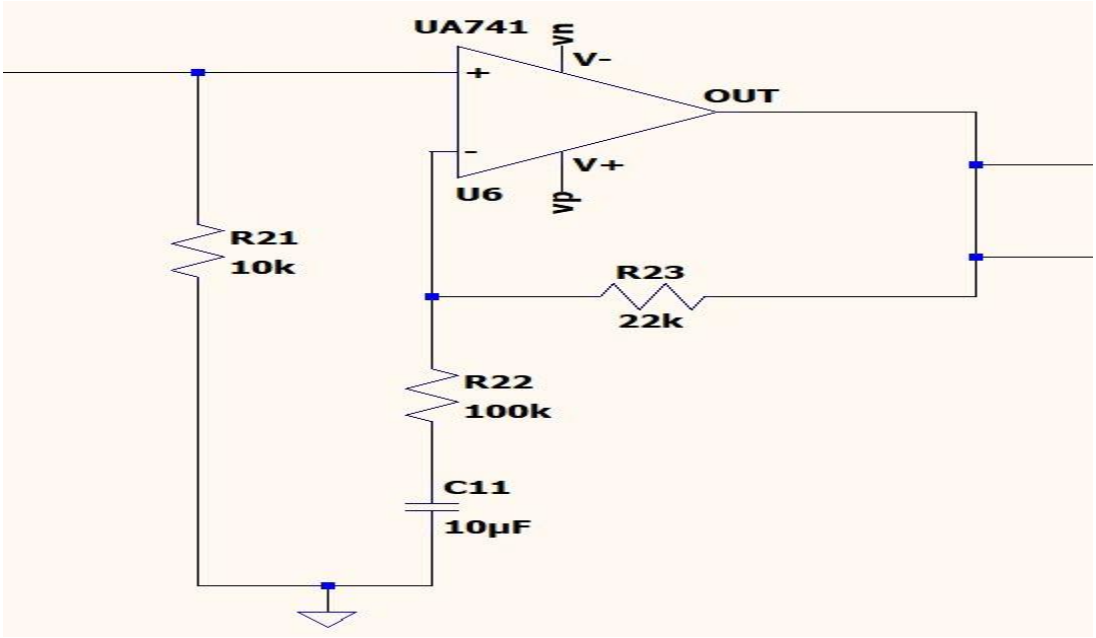
Circuit Diagram

We developed the main circuit diagram at LTSpice. The schematic is given below-



Sub-circuit Explanation

1. Pre-Amplifier –



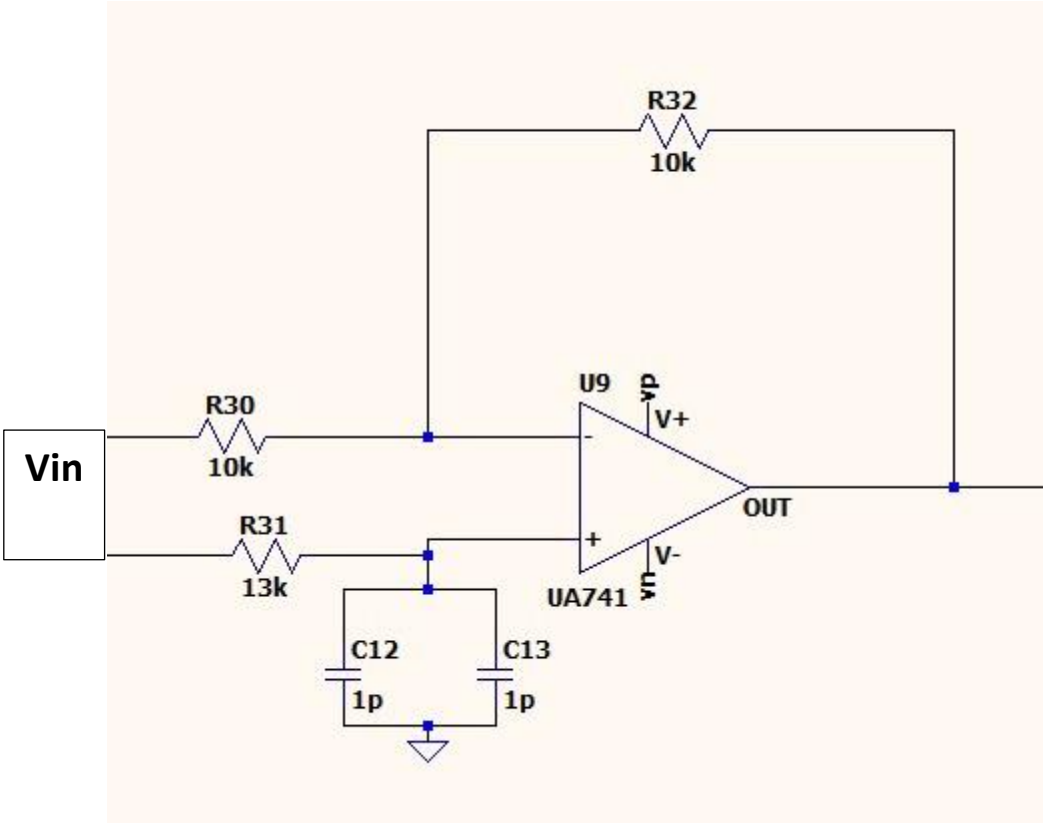
This stage amplifies the noise caught by the external microphone to a higher level because the waves themselves are tiny and would result in minimum voltages. The gain here is defined by the ratio of the resistors.

$$\text{Gain} = \frac{\text{R23}}{\text{R22}} = \frac{22\text{k}}{100\text{k}} = 0.22$$

Here we have set a very small gain for theoretical reasons as the noise is set up manually. Practically, the gain can be high or low according to noise amplitude. There is a rheostat for gain changing.

The capacitor reduces the DC offset. DC components will cause issues that will compound as the signals travel through the circuit and will result in a poorly working system. From here the noise will pass to the delay.

2.Delay Filter –



The delay filter provides the delay to the noise-canceling signal that helps align all the signals and noise so that the summing process is much more effective. We have also known the speed difference of sound and electric signals. As a result, the noise from the actually will arrive an instant later than the noise from the circuit to the ear.

If the distance from the external microphone to the ear is L , the speed of sound is and the time delay is t ,then formula is , L=Vs * t

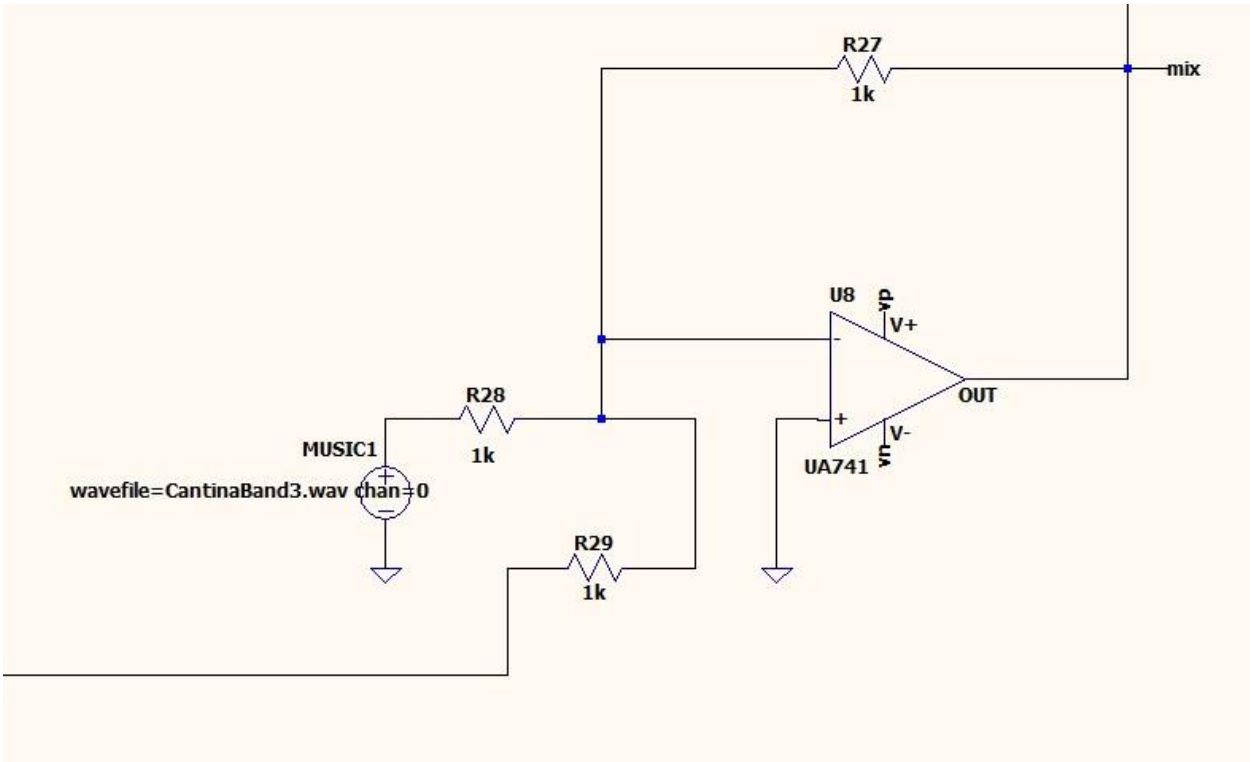
$$\text{Therefore, } t = \frac{L}{Vs}$$

Here above circuit, if superposition is applied, the equation $\frac{Vout}{Vin} = \frac{(1-jwRC)}{(1+jwRC)}$; where C=C12+C13 [Only phase is considered]

Therefore, $V_{out} = [-2 \tan^{-1}(wRC)] * V_{in}$

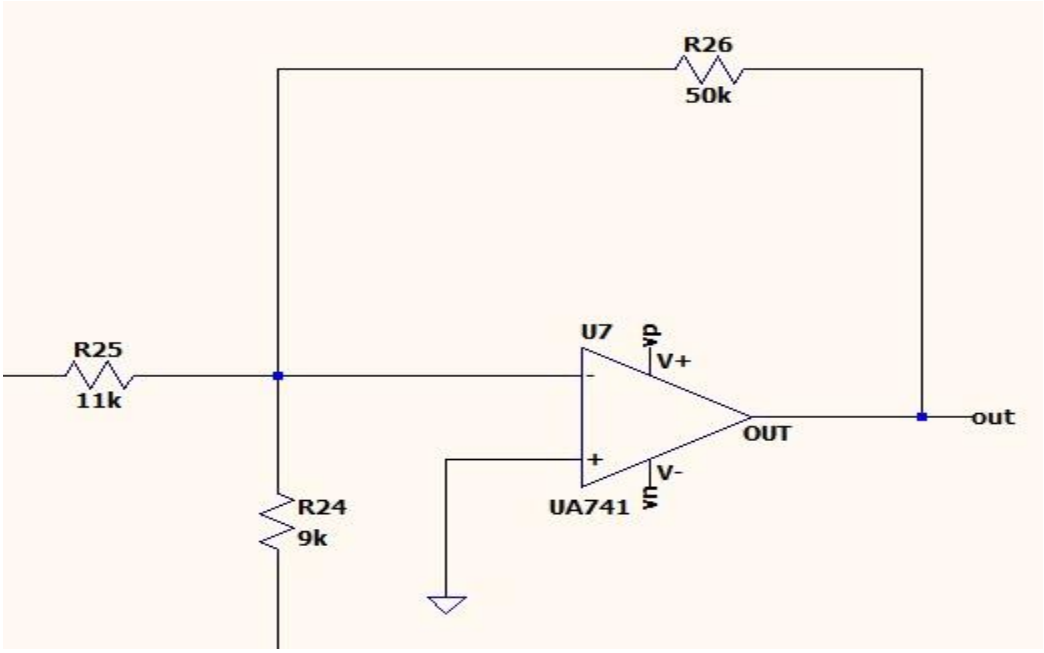
Here we see that output is lagging from the input. And it depends on R31, C12 & C13.

3.Inverting Summer –



Inverting summer (3) mainly takes the music as input . Surrounding noise will also be added with music as well. Then it gets inverted with a particular gain .

$$\text{Gain} = \frac{R27}{R28} = \frac{R27}{R29}$$

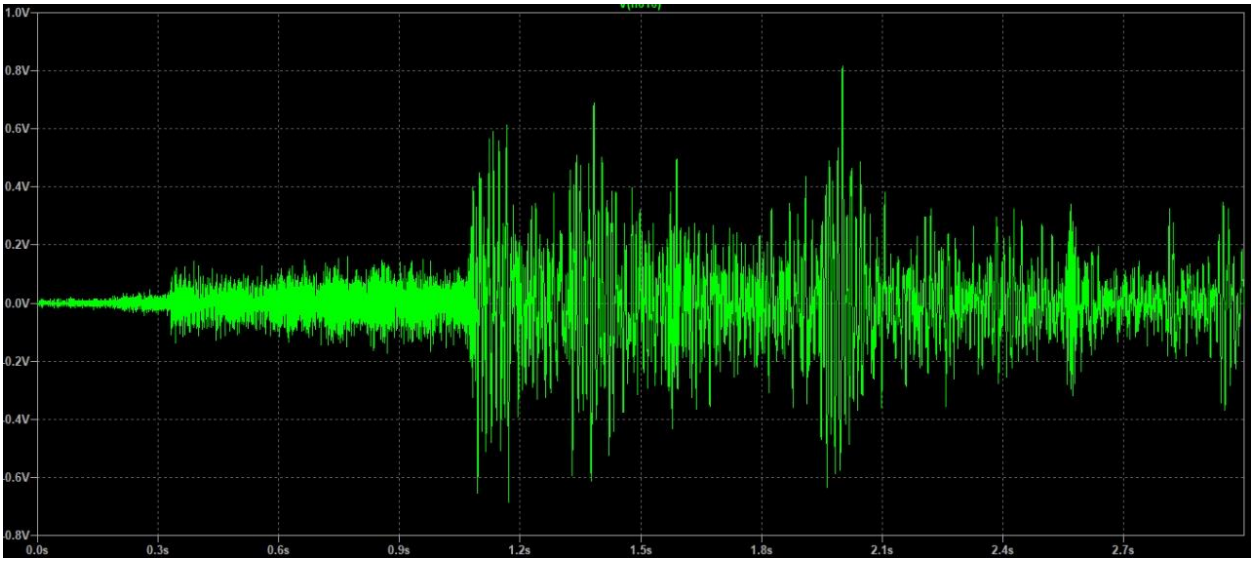


The final stage is inverting summer (4). It combines the amplified noise with an output of the amplifier(3). Then the noise and mixed one are summed up. Here the phase of noises is the opposite. To eliminate it, we have to equal the magnitude. Thus the gain is achieved. And as noise gets subtracted , we get the desired noise-free music.

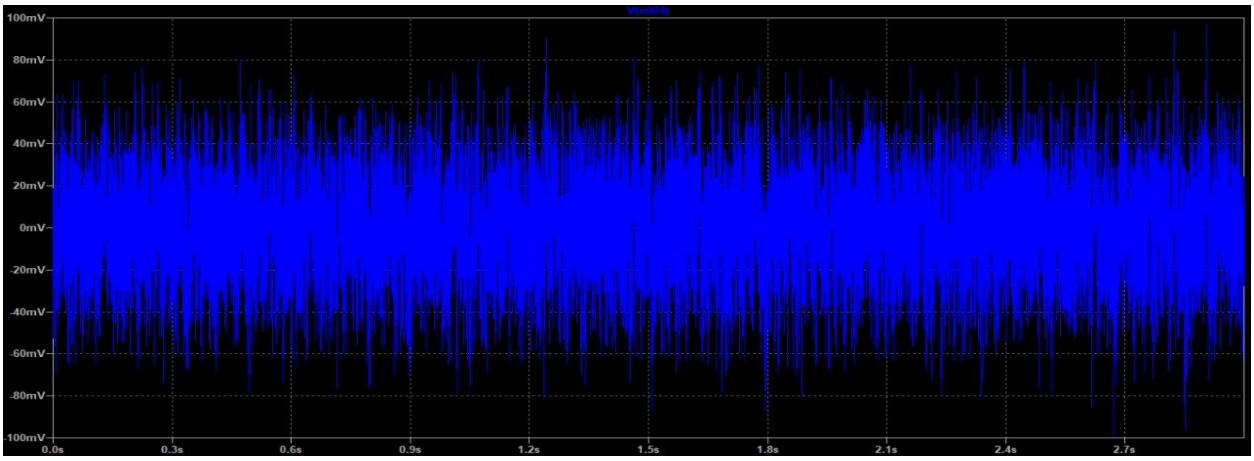
Sample Input Output Cases

Wave Plot—

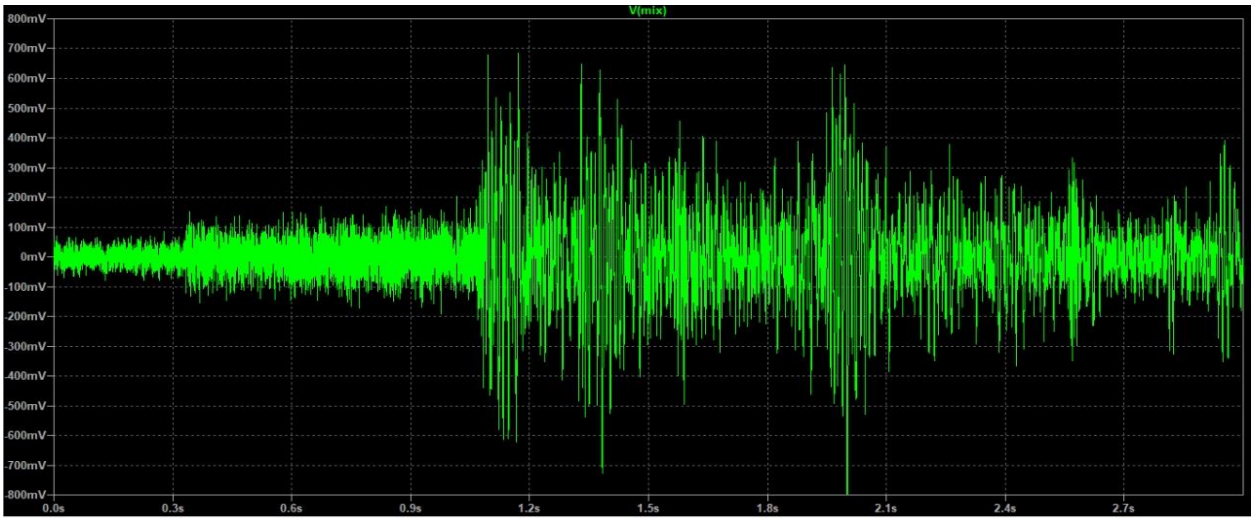
Main Music –



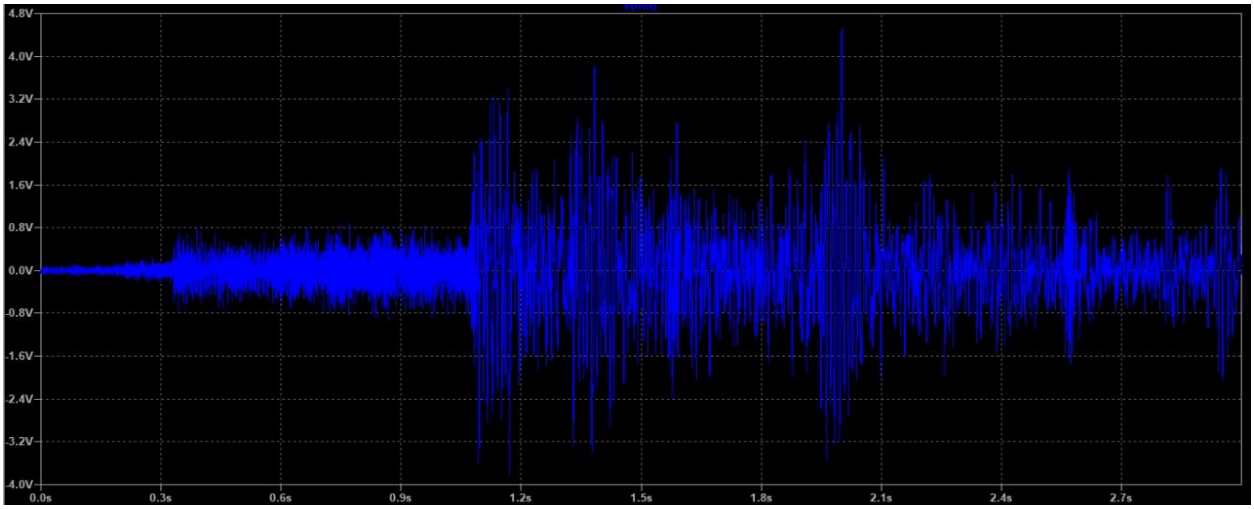
Noise—



Mixed (Music+Noise)—



Output—



Some test case of audio file is attached with the drive link below—

https://drive.google.com/drive/folders/1izbRnT9g-CM4l_Qj7F9NV5h1O_RO4i-i?usp=sharing

Limitations

In project, we gave noise manually and eliminated it. So there should be no error. But there are two limitations we have to talk about—

- The delay filter we used basically had no effects on the circuit. As capacitance was very low, the shifting was also low. But in a real headphone circuit, it is very important to maintain an appropriate phase sequence between electric and sound signals.
- The pre-amplifier is used to maintain the proper magnitude. But here as the noise was in our hand, so this stage had no values in the circuit. But practically, it is important.

Future Work

Active noise cancellation is a problem solution-based project, which enhances the experience of hearing. But it is not the ultimate enhancing tool. Besides active noise cancellation, there are other stuffs like audio mixing, equalizers, etc. Active noise cancellation is the first step toward higher-level projects for a better hearing experience. Other than those, this project will help in many fields, including manufacturing noise-canceling earphones, in places where the desired sound is very low compared to the noise present. This can be of help to the people who work in a heavy noisy workplace resisting them to suffer from hearing problems.

Discussion

There are many kinds of noises around us, everywhere, which hampers the quality of the sounds we intend to take from hearing audio devices, i.e. earphones. The noises are classified according to the frequencies present and the amplitude of the frequencies and given names as colors, white, blue, pink etc. We have used pink noise as noise input for our project. In the project, we tried to model the noise cancellation circuit keeping the practical life details in the kind. We added the delay filter, and pre amplifier which may not have an effect in this circuit, but will have in

the practical implementation. We will keep the resistance in the preamplifier and the delay filter to adjust in real time.

Noise cancellation seem extra from the surface but it has various applications which are utterly necessary. It can be helpful to many people to save their ears from heavy noises, filter desired outputs from the external noises to get a better result in sound-related experiments etc. The project may look small but will have greater effects on peoples' life.

The End