ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING.

Network Analysis and Synthesis

Group Project

TITLE: BUILDING AUDIO EQUALIZER FOR MUSIC STREAMING APP USING LOWPASS FILTER.

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Catalog

INTRODUCTION

The purpose of this experiment is to design and simulate a filter that can preserve audio frequencies below 4 kHz while effectively eliminating unwanted high-frequency noise. The experiment is conducted in the context of a music streaming app that allows users to adjust the bass and treble levels. However, the app is facing issues related to high-frequency noise, which is negatively affecting the audio quality.

To address this problem, the experiment focuses on designing a filter that can attenuate or reduce the unwanted noise while minimizing the impact on the passband. The desired outcome is to achieve a passband attenuation of less than 3 dB, ensuring that the audio quality remains relatively unaffected for frequencies below 4 kHz.

The filter design process involves careful consideration of the frequency response characteristics and filter parameters. Various filter types and designs can be explored, such as low-pass filters, high-pass filters, or band-stop filters, depending on the specific requirements of the application.

Simulations play a crucial role in this experiment, allowing for a comprehensive evaluation of different filter designs and their performance. Simulating the filter response helps in assessing the extent of noise attenuation, the impact on the audio signal, and ensuring that the desired passband attenuation requirements are met.

By conducting this experiment, the aim is to find an optimal filter design that effectively addresses the high-frequency noise issue, while minimizing any detrimental effects on the audio quality. The results obtained from the simulations will provide valuable insights for implementing the filter in the music streaming app, ultimately enhancing the user experience by delivering cleaner and more enjoyable audio playback.

PROBLEM STATEMENT

The problem addressed in this experiment is the presence of high-frequency noise that is negatively affecting the audio quality in a music streaming app. While the app allows users to adjust the bass and treble levels, the unwanted noise above 4 kHz is causing a degradation in the overall listening experience.

The objective of this experiment is to design and simulate a filter that can effectively eliminate the high-frequency noise while preserving audio frequencies below 4 kHz. The filter should maintain a passband attenuation of less than 3 dB to minimize any adverse impact on the desired audio signals.

The specific challenges to be addressed include

A)Noise Elimination: Designing a filter that can efficiently attenuate or eliminate the high-frequency noise while maintaining the integrity of the desired audio signals below 4 kHz.

B)Passband Preservation: Ensuring that the filter design minimizes any distortion or alteration of the audio frequencies below 4 kHz, allowing users to adjust the bass and treble levels without significant degradation.

C)Attenuation Requirement: Achieving a passband attenuation of less than 3 dB to maintain audio quality and prevent any noticeable reduction in the desired audio signals.

By successfully addressing these challenges, the experiment aims to enhance the audio quality of the music streaming app by effectively reducing the impact of high-frequency noise. This will provide users with a more enjoyable and immersive listening experience, while still allowing them to customize the bass and treble levels to their preference.

GENERAL AND SPECIFIC OBJECTIVES

General Objective:

The general objective of this experiment is to improve the audio quality of a music streaming app by designing and simulating a filter that effectively eliminates high-frequency noise while preserving audio frequencies below 4 kHz. The aim is to enhance the overall listening experience for app users.

Specific Objectives:

Design an Effective Noise Elimination Filter: Develop a filter design that efficiently attenuates or eliminates high-frequency noise. Ensure that the filter effectively removes unwanted noise while minimizing any distortion or alteration of the desired audio signals below 4 kHz.

Maintain Passband Integrity: Design the filter to preserve the desired audio frequencies below 4 kHz without significant degradation. Allow users to adjust the bass and treble levels within the passband without noticeable loss in audio quality.

Achieve Passband Attenuation: Ensure that the designed filter meets the requirement of a passband attenuation of less than 3 dB.

Verify through simulations that the filter effectively reduces the unwanted noise while keeping the desired audio signals relatively unaffected.

1. *Simulate and Evaluate Filter Performance:*
- Utilize simulation tools to evaluate the performance of the designed filter.
- Analyze the filter's frequency response, passband attenuation, and overall impact on the audio signals.
- Compare and assess different filter designs to identify the most suitable solution for the music streaming app.

2. *Enhance User Experience:*
- Provide cleaner and higher-quality audio playback by reducing the impact of high-frequency noise.
- Improve the overall user experience by delivering enhanced audio fidelity and clarity through the implemented filter.

By achieving these specific objectives, the experiment aims to address the high-frequency noise issue and enhance the audio quality of the music streaming app, ultimately providing users with a more enjoyable and immersive listening experience.

METHODOLGY

Problem Understanding:
- Gain a comprehensive understanding of the high-frequency noise issue in the music streaming app and its impact on audio quality.
- Identify the specific requirements and constraints for designing a filter that preserves frequencies below 4 kHz while attenuating unwanted noise.

Filter Design:
- Based on the research findings, design a filter that meets the requirements of the experiment.
- Determine the appropriate filter parameters, such as cutoff frequency, filter order, and filter response characteristics, to achieve the desired noise elimination and passband preservation.

- Where ours is

  $\alpha p < 3\text{dB}$ $\quad 0<\omega p<4\text{kHz}$

  $\alpha s > 20\text{dB}$ $\quad \omega s > 7.104$

  Ə =1

  K=$\omega p/\omega s$= 0.563

  $$\text{K1} = \sqrt{\frac{10^{0.1ap}-1}{10^{0.1as}-1}}$$

  K1= 0.1005

  $$\text{n} \geq \frac{cos^{-1}(\frac{1}{k})}{cos^{-1}(\frac{1}{k1})}$$

  n = 3

To find T(s), we use the poles on the left hand side

$$s_k = \sigma_k + j\psi_k$$

$$\sigma_k = \sinh\nu \sin\left(\frac{2k+1}{2n}\pi\right), k = 0,1,2,\ldots,2n-1$$

$$\psi_k = \cosh\nu \cos\left(\frac{2k+1}{2n}\pi\right)$$

$$\nu = \frac{1}{n}\sinh^{-1}\frac{1}{\varepsilon}$$

Then T(s) becomes:

$$\frac{1}{s^3 + 0.596s^2 + 0.9268s + 0.25}$$

Then

$$\rho(s) = \frac{s^3 + 0.75s}{s^3 + 0.596s^2 + 0.9268s + 0.25}$$

Thus the transfer function will be:

$$\text{Z(s)} = \frac{1+p(s)}{1-p(s)} = \frac{2s^3 + 0.596s^2 + 1.6768s + 0.25}{0.596s^2 + 0.1768s + 0.25}$$

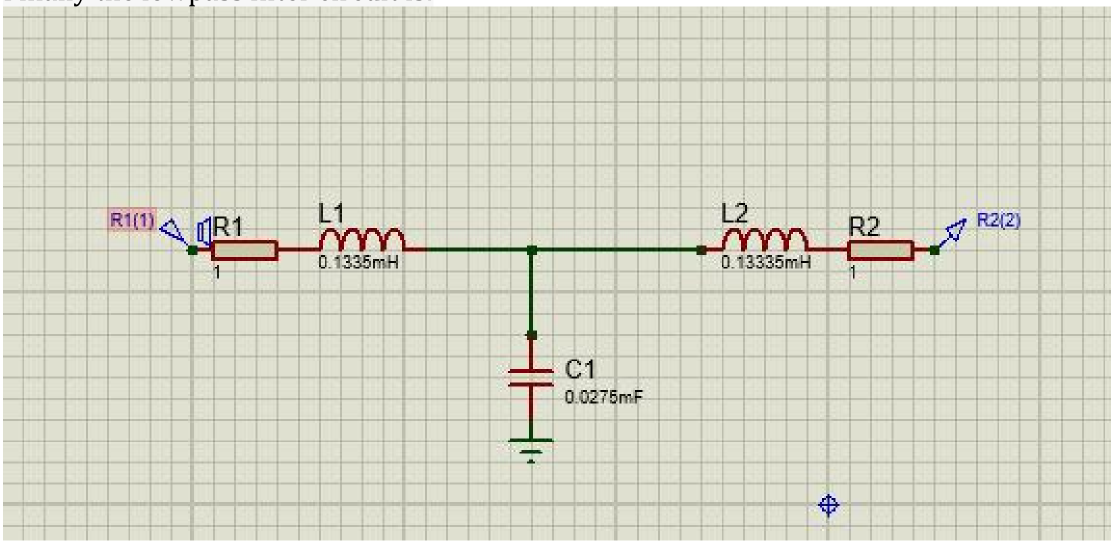
After cauer long division:

L_1=3.3557H $\quad L_2$=3.351H $\quad C_1$=0.692F

But after normalization of the values by($2\pi \times 4kHz$)

L_1=0.1335mH $\quad L_2$= 0.13335mH $\quad C_1$=0.0275mF

Finally the lowpass filter circuit is:



Filter Simulation and Analysis:

- Implement the designed filter in the selected simulation tool.
- Simulate the filter's response to input signals containing high-frequency noise and desired audio frequencies.

Analysing the filter's frequency

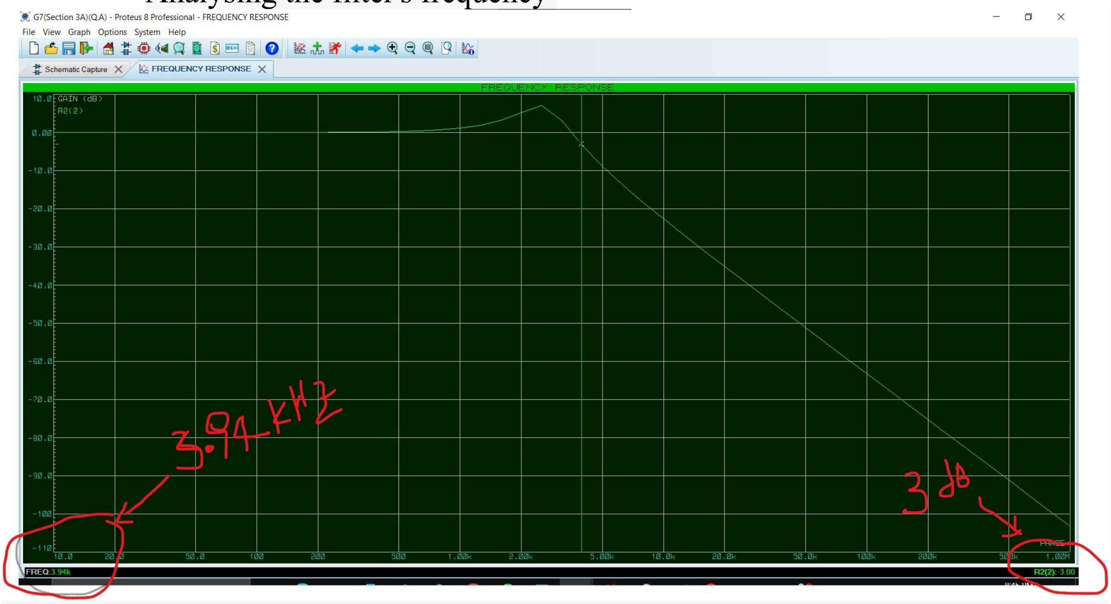


Fig. Frequency response

SIMULATION AND DISCUSSION

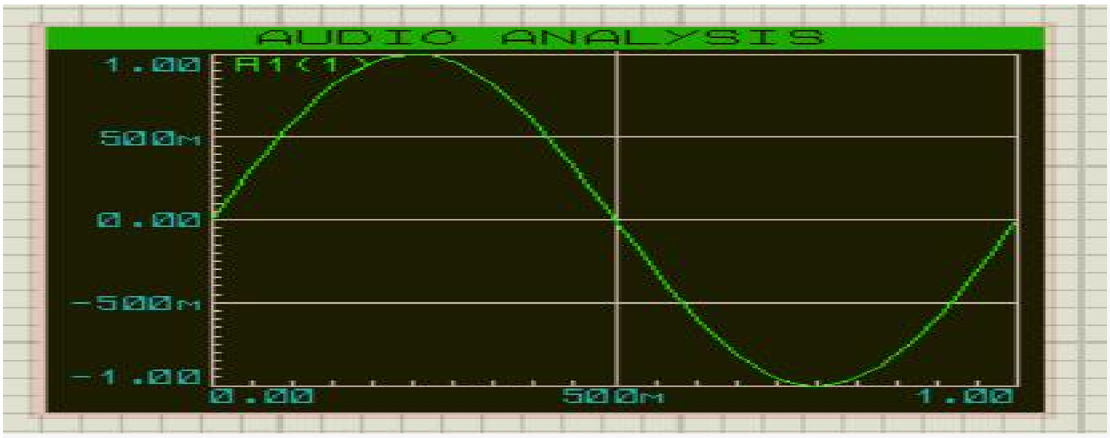


Fig. Sine wave input

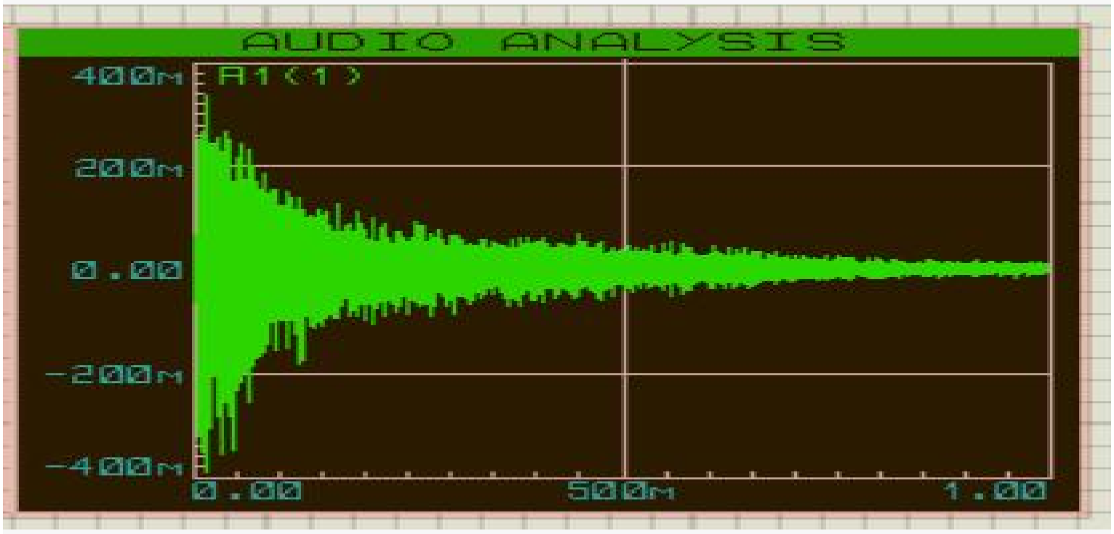


Fig. Audio input wave form

Fig. Sine wave output

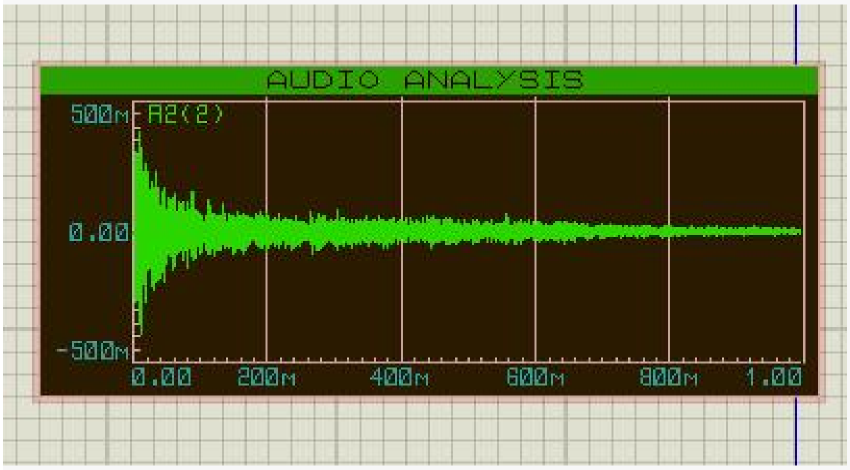


Fig. Audio output wave form

Comparing the performance of different filter designs by considering factors such as passband attenuation, noise reduction, and impact on audio quality.
The experiment can systematically approach the problem of high-frequency noise in the music streaming app and design an appropriate filter that effectively addresses the issue while maintaining audio quality. The use of simulations allows for thorough evaluation and optimization of the filter design before its implementation in the app.

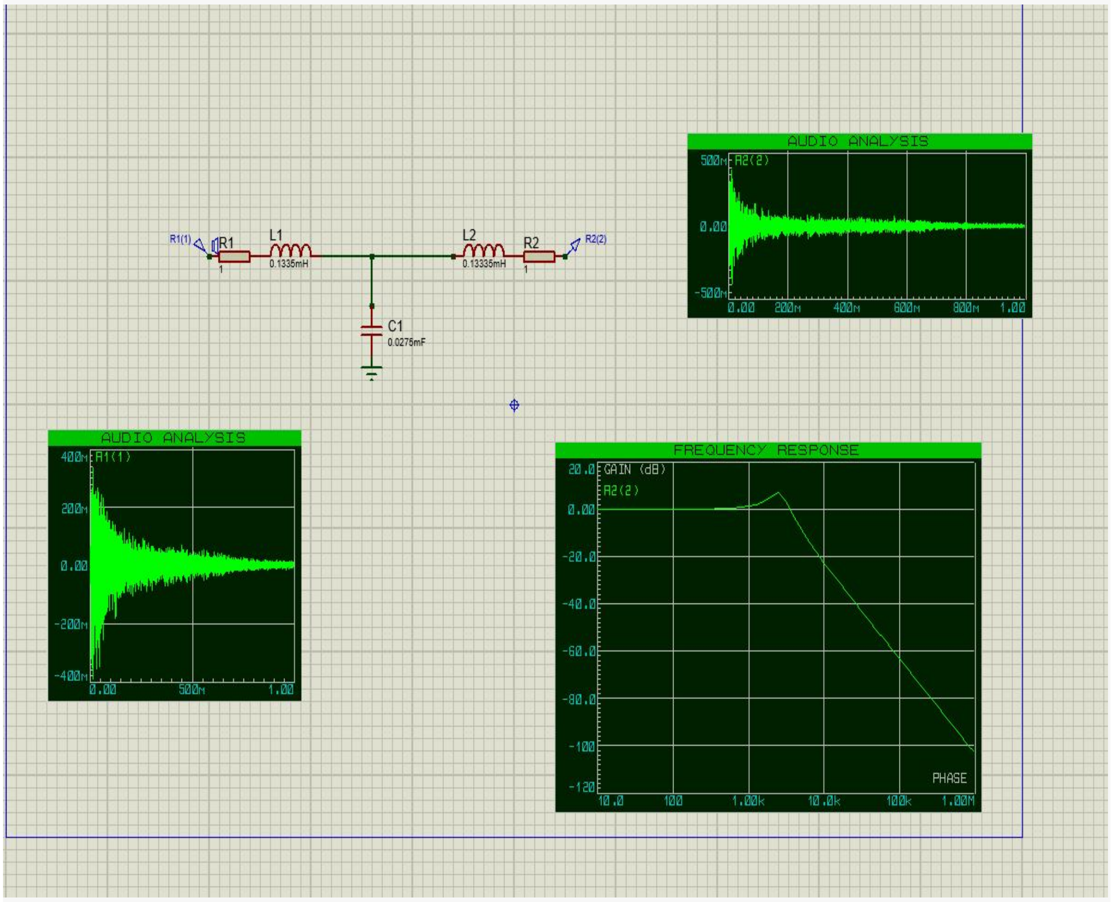


Fig. Input, output and frequency response graph

CONCLUSION

This project on low pass filter successfully illustrated its fundamental function of attenuating higher frequencies while permitting lower frequencies to pass through with minimal loss. This practical demonstration reinforces the essential role of low pass filters in various electronic applications, such as signal conditioning and noise reduction, highlighting their effectiveness in shaping and refining signals according to desired frequency characteristics.

The design and implementation phase provided valuable hands-on experience, emphasizing the importance of careful component selection and precise tuning to achieve optimal filter performance. The use of simulation tools such as Proteus facilitated a thorough understanding of filter behavior before physical implementation, thereby reducing trial-and-error in the prototyping stage.

Furthermore, the project highlighted the adaptability of low pass filters in both analog and digital domains. While analog filters are essential for real-time signal processing, digital filters offer flexibility and precision in applications requiring complex filtering algorithms. This dual approach underscores the broad applicability of low pass filters across various technological landscapes.

REFERENCES

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