Department of Electronic & Telecommunication Engineering, University of Moratuwa,
Sri Lanka.

Audio Voice Over Circuit

Group Members:

220061H	Bandara I.W.T.N
220711D	Wijenayaka M.B.T.I
220596C	Senaweera S.A.H.D
220577U	Sanjeewa P.M.G.P.N

Submitted in partial fulfillment of the requirements for the module
EN 2091 Laboratory Practice and Projects

18-12-2024

0.1 Abstract

This report presents a detailed account of the approach utilized in the making of the audio voiceover circuit, allowing users to effortlessly alternate between the audio input and the microphone input according to their preference. The project integrates critical elements such as amplifiers, switching mechanisms, filters, and various operational amplifier circuits, guaranteeing reliable and efficient performance.

The preliminary design and simulation stages were done using Proteus 8 Professional software, enabling accurate analysis and verification of the circuit's functionality. . SolidWorks software was used for the mechanical design of the circuit's enclosure, ensuring an efficient and visually appealing design that satisfies structural standards. Additionally, Altium Designer was used to design the printed circuit board, facilitating a precise and thorough arrangement of the electronic components to correspond to industry standards.

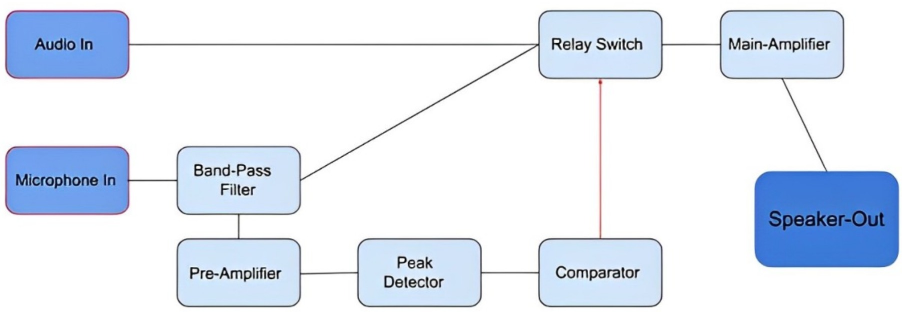
This report delivers broad insight into every phase of the design process, explaining the approaches and tools employed in making the audio voice-over circuit.

Contents

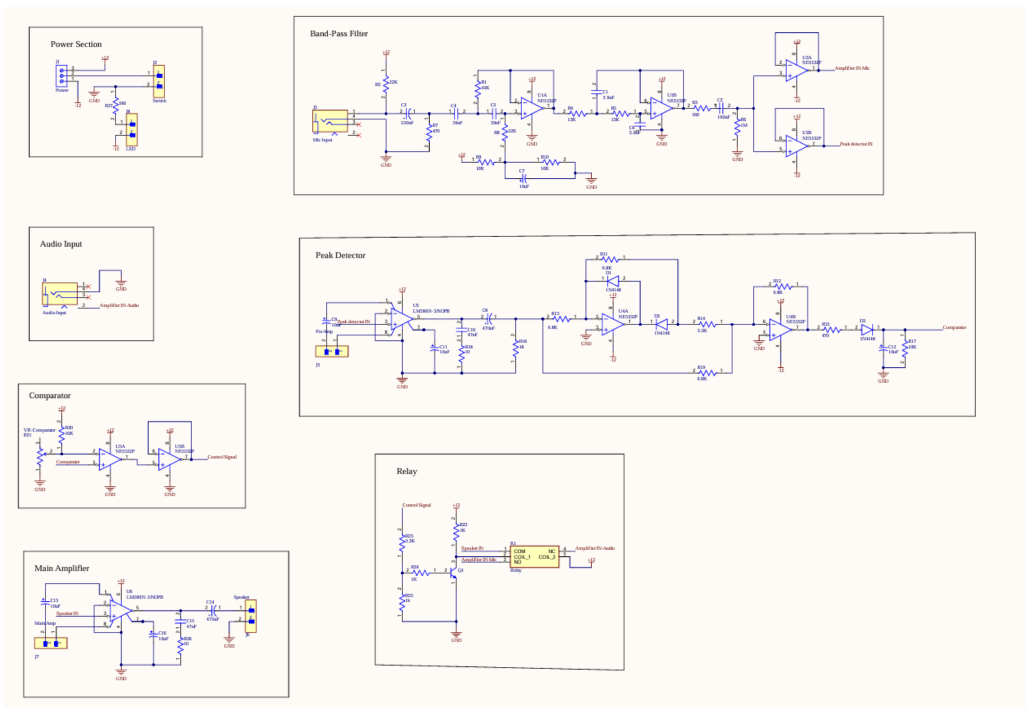
1 Introduction

The primary objective of this audio voice-over circuit project is to engineer a high-quality circuit that effortlessly transmits either the audio input or microphone input according to user preference, guaranteeing minimal noise, echo suppression, and optimal clarity. In contrast to conventional circuits that encounter issues with echo, noise, and switching delays, our project integrates many circuits employing Op-Amps, transistors, and relays to attain low noise, rapid and efficient switching, and echo suppression. This method ensures seamless functionality, distinct audio transmission, and dependable performance.

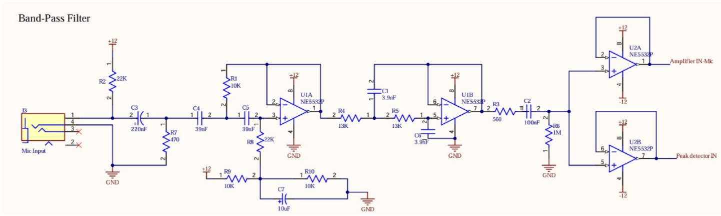
2 Functional Block Diagram and Functionality



The integrated circuit consists of six primary functional blocks that are interconnected to ensure stable and high-quality audio output.



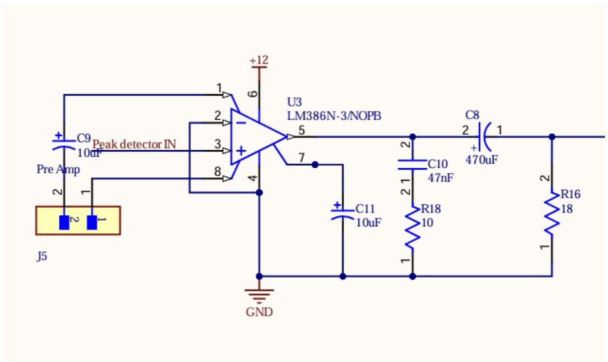
2.1 Band-Pass Filter



This band-pass filter integrates passive and active filtering methods to isolate a particular frequency region. The microphone input is linked via a coupling capacitor (C3) that blocks DC offset, permitting only AC signals to transmit. The R2 resistor biases the input signal, whilst R7 establishes the impedance to stabilize the circuit.

The initial stage constructed with the NE5532 dual low-noise operational amplifier functions as an active high-pass filter. The cutoff frequency is determined by components R1, R7, C4, and C5. The second stage functions as a low-pass filter employing R4, R5, C6, and related components to remove high frequencies. Collectively, these stages form the band-pass filter, allowing frequencies between 500 and 5000 Hz to pass through.The filtered signal is then fed to a gain amplifier to improve the signal amplitude, in addition to a peak detector.

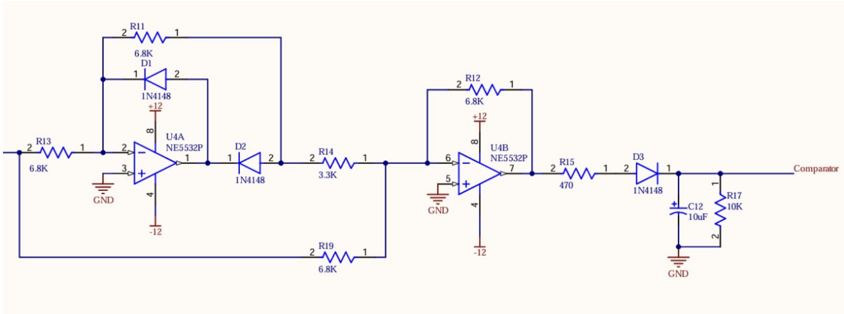
2.2 Pre-Amplifier



This preamplifier is designed to amplify the audio signal output from the bandpass filter to a level enough for detection by a peak detector circuit. The LM386N operational amplifier is used in this circuit because of its suitability for audio applications.

The input signal is sent through the C9 capacitor, which prevents any DC component while allowing just the AC signal from the band-pass filter to pass through. The LM386 amplifier relies on a +12V supply, with C11 functioning as a bypass capacitor.The gain of the LM386 is determined by C10 and R18.Capacitor C10 is connected between pins 1 and 8 to enhance the amplifier's gain. Resistor R18 collaborates with capacitor C10 to establish bandwidth and stability. Capacitor C8 stabilizes the output, while resistor R16 restricts current flow and establishes the load impedance.

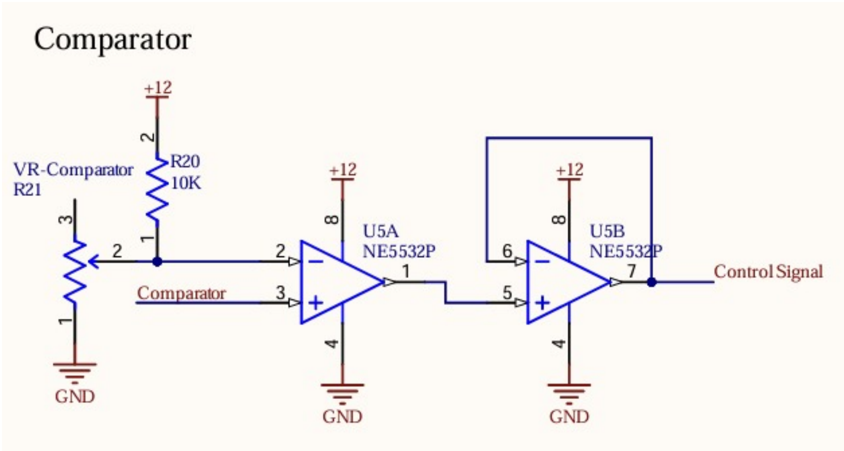
2.3 Peak Detector



This peak detector circuit was constructed using mainly two NE5532P Op-Amps and additional components to detect the peak amplitude of the input audio signal coming from the preamplifier circuit and transform it into a stable DC voltage.

The input audio signal is initially applied to the non-inverting input of the first NE5532P operational amplifier, which is designed as a buffer to mitigate loading and distortion. The buffered output is then rectified with a 1N4148 diode, which charges capacitor C12 to the signal's peak voltage. The capacitor retains this voltage due to the diode preventing discharge back into the op-amp. A discharge resistor R17 ensures a steady decrease of the capacitor voltage over time.The voltage across C12 is subsequently buffered by the second NE5532P operational amplifier to avoid any additional loading of the peak voltage. The consistent DC voltage, corresponding to the peak amplitude of the input signal, is output through D3 and acts as an input to the comparator circuit.

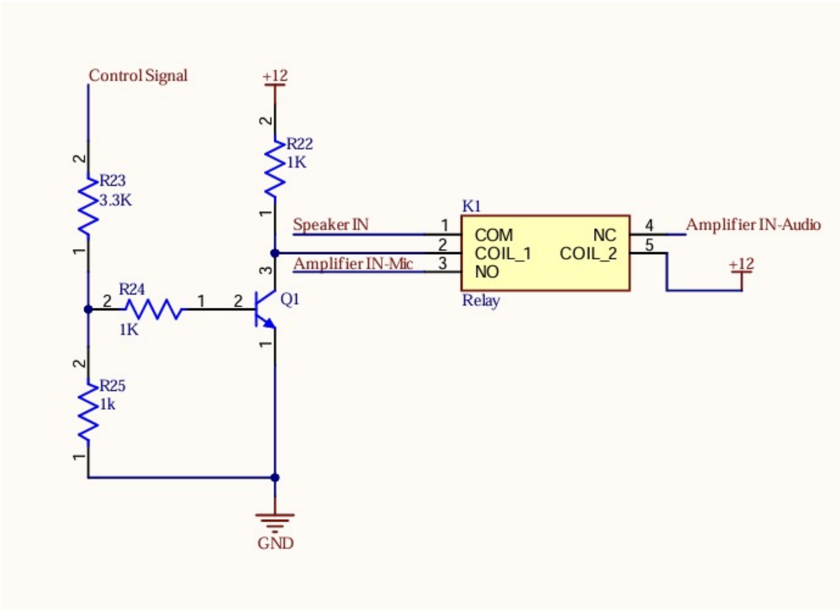
2.4 Comparator



The comparator circuit utilizes the NE5532P dual operational amplifier integrated circuit. The input signal from the peak detector circuit is applied to the inverting input of the first op-amp (U5A) via a voltage divider composed of R20 and R21, establishing a reference voltage at the non-inverting input.

When the input signal surpasses the reference voltage, the output of U5A transitions state, thereby comparing the signal with the threshold level. The threshold level can be adjusted properly using the trimmer.The output of U5A is subsequently directed to the second operational amplifier U5B, which functions as a buffer, isolating the comparator circuit from the switching circuit. This configuration prevents the comparator's output from getting affected by the transistor in the switching circuit and guarantees a stable and clean control signal.

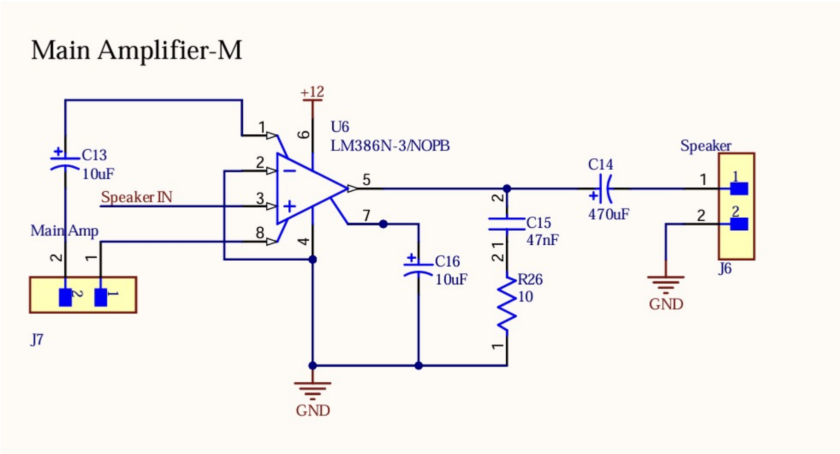
2.5 Switching Circuit



The switching circuit employs a 2N3904 NPN transistor and a relay to alternate between two inputs: a microphone and an audio input. The circuit's core is the 2N3904 transistor, controlled by the comparator circuit's output, toggling the transistor on or off in response to the incoming signal.

The relay's Normally Open (NO) and Normally Closed (NC) contacts determine the input signal (either the microphone or audio) directed to the amplifier. Upon activation of the transistor, current flows through it, switching the relay (K1) from NC (audio input) to NO(microphone input) .The resistors (R22, R23, R24, R25) provide essential biasing for the transistor and limit current to guarantee the circuit's proper functionality.

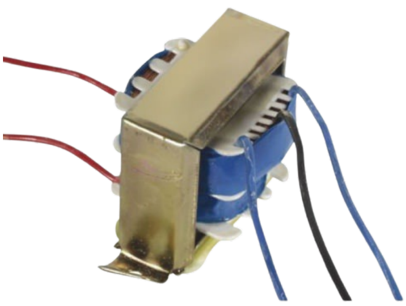
2.6 Main Amplifier

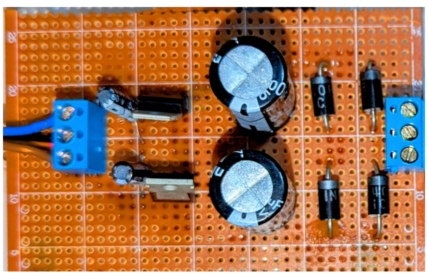


The Main amplifier circuit employs the LM386N Op-Amp IC, a low-voltage audio power amplifier designed to boost audio signals.

The input signal (MIC input or the AUDIO input) is transmitted through capacitor C13 (10µF) to the non-inverting input of the LM386N. The amplifier's gain can be modified by external components linked between pins 1 and 8, while capacitors C14 (470µF) and C15 (47nF), in conjunction with resistor R26 (10Ω), facilitate filtering and stability, ensuring seamless operation without oscillations.The amplifier improves the amplitude of the incoming audio signal, facilitating clear and robust sound output to the speaker. Capacitor C14 functions as a coupling capacitor, preventing DC offset from reaching the speaker, whereas C16 (10µF) assists with power supply filtration.

2.7 Power Section





We used a 12V 1A center tap transformer working together with a rectifier circuit, which we soldered onto a dot board, to produce a dual rail 12V power supply necessary for the proper functioning of the Op-Amps.

3 Component Selection and Justification

3.1 LM386N Audio Amplifier IC

- **Low Power Consumption**
  The LM386N functions effectively with minimal power consumption, making it suitable for battery-operated or portable applications. It operates within a power supply range of 4V to 12V, providing flexibility in low-voltage configurations.

- **Easy gain control**
  The LM386N allows easy gain modification, typically ranging from 20 to 200, without the requirement for external feedback networks. Introducing just one capacitor between pins 1 and 8 enhances the gain, allowing for significant customization to meet various audio amplification requirements.

- **High Output Power**
  Despite its small dimensions, the LM386N is capable of delivering an output power of up to 0.7W, adequate for small to medium-sized audio devices such as headphones, compact speakers, or intercom systems.

- **Low Quiescent current**
  The IC has a low quiescent current of 4mA (typical), meaning it consumes very little power when there is no input signal. This is essential for devices that need to conserve power during idle times.

- **Built in protection**
  The LM386N includes features like internal thermal shutdown and short-circuit protection. This makes it robust and durable in consumer electronics, preventing damage from overcurrent or overheating conditions.

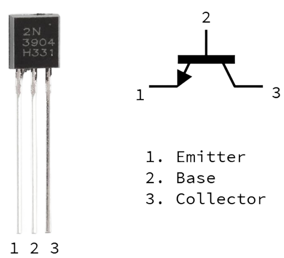
3.2 NE5532P Dual Op-Amp IC

- **Low Noise Performance**
  The NE5532P offers exceptionally low noise performance, making it suitable for high-fidelity audio applications. It preserves clarity in the enhanced signal by reducing background noise and hum, which is essential for audio systems such as preamplifiers, mixers, and audio processing devices.

- **Low Staturation Voltage**
  The saturation voltage of the 2N3904 is rather low, approximately 0.2V. This indicates that while the transistor is ”on” (in saturation), it has a minimal voltage drop across the collector-emitter junction, hence reducing power loss and facilitating efficient switching.

- **Low power consumption**
  The 2N3904, with a collector current capacity of 200mA and a maximum power dissipation of 625mW, is ideal for low-power switching applications, like the control of small relays, LEDs, or other low-power devices.

3.3 2N3904 Transistor

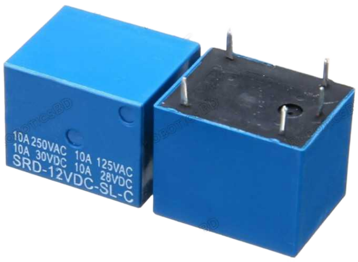


- **Fast Switching Speed**
  The 2N3904 exhibits a high switching speed, making it appropriate for applications demanding rapid transitions between on and off states.

- **Dual Op-Amp package**
  The NE5532P contains two op-amps in one package,this not only simplifies the design but also reduces the number of components needed, making the circuit more compact and efficient.

- **High Slew Rate**
  The operational amplifier features a high slew rate of 9 V/µs, indicating its capability to swiftly respond to sudden changes in the input signal. This renders it exceptional in handling dynamic audio signals, guaranteeing precise reproduction of rapid changes in music and other audio sources.

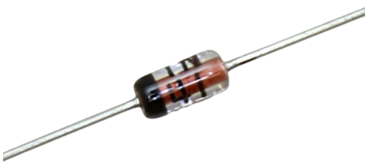
3.4 12V mechanical Relay



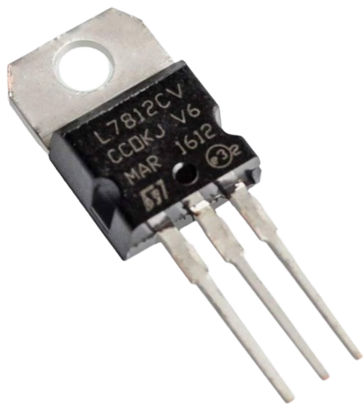
- **High current and voltage handling**
  Relays are capable of switching larger currents and voltages compared to solid-state devices such as transistors or MOSFETs. In an audio circuit, this is crucial for controlling greater loads, such as speakers, amplifiers, or various audio sources, without jeopardizing the functionality of the switching components.

- **Minimal signal distortion**
  Mechanical relays, in contrast to certain semiconductor-based switches, do not induce distortion or interference in the signal pathway. This is vital in audio applications where preserving flawless high-quality sound is crucial. The relay's contacts either fully engage or disengage the audio signal without alteration.

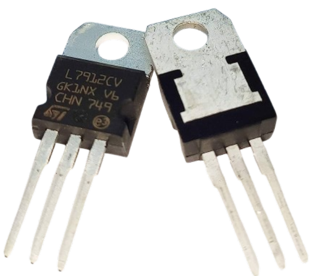
3.5 other components



1N4148



L7812 voltage regulator

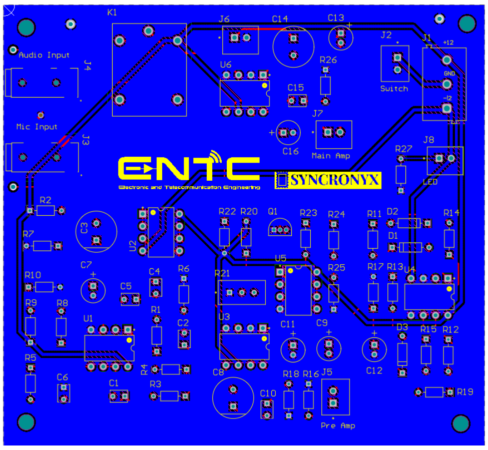


L7912 voltage regulator

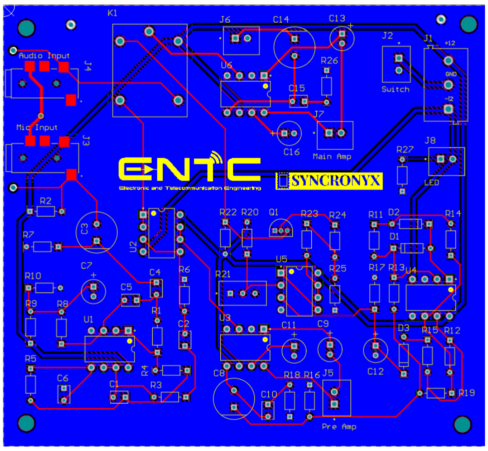
speaker

4 PCB Design

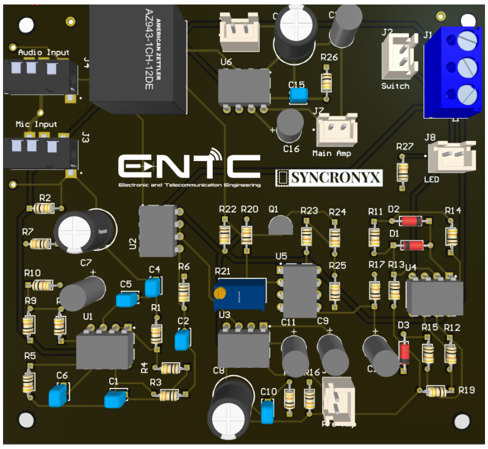
4.1 Bottom Layer



4.2 Top Layer

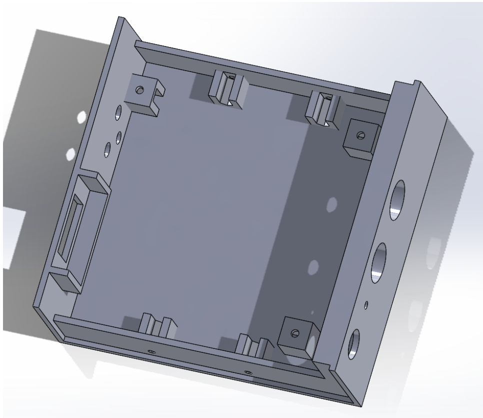


4.3 3D View

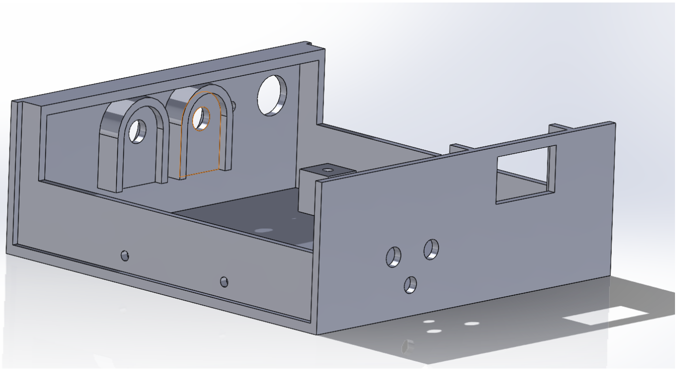


5 Enclosure Design

5.1 Bottom chasis

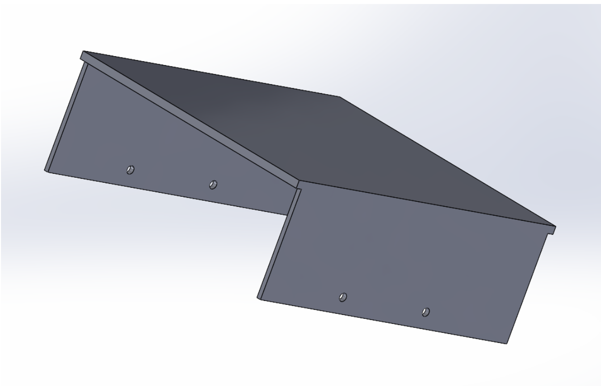


top view

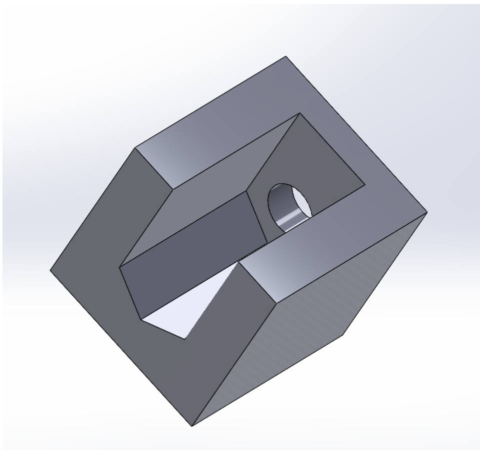


front view

5.2 Top chasis and Spacer hole

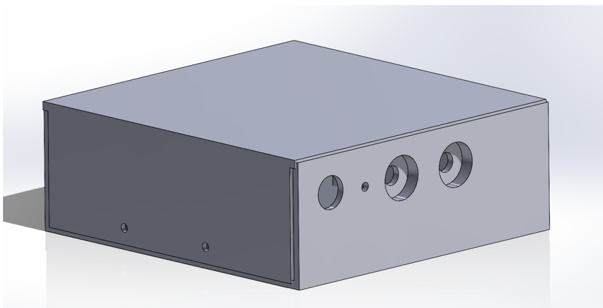


top chasis

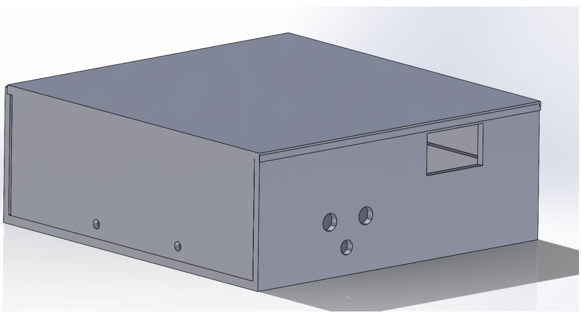


spacer hole

5.3 Final chasis



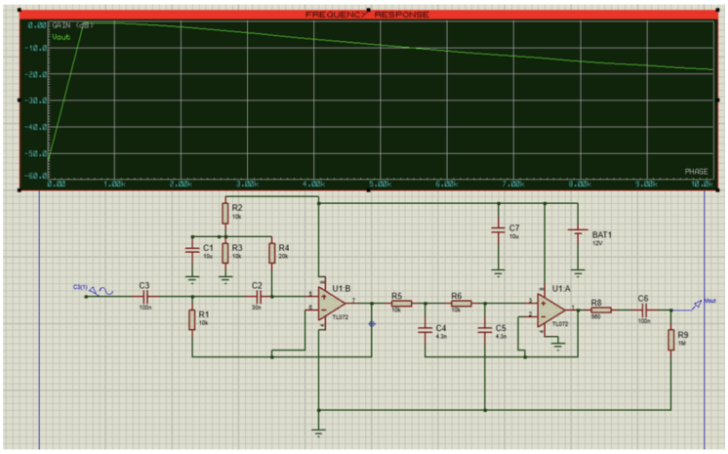
front view



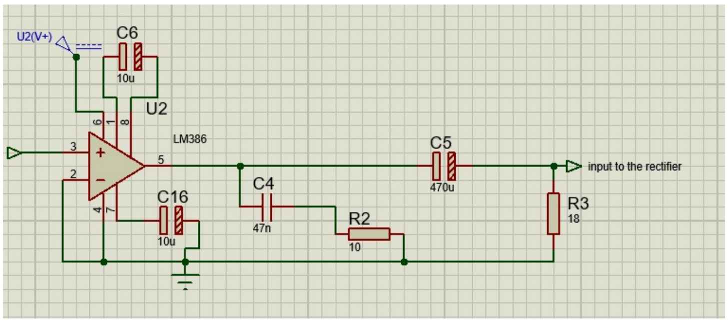
back view

6 Software Simulation and Hardware Testing

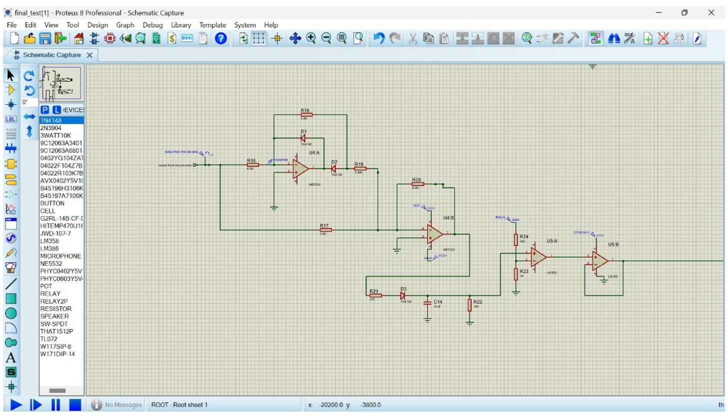
6.1 Bandpassfilter



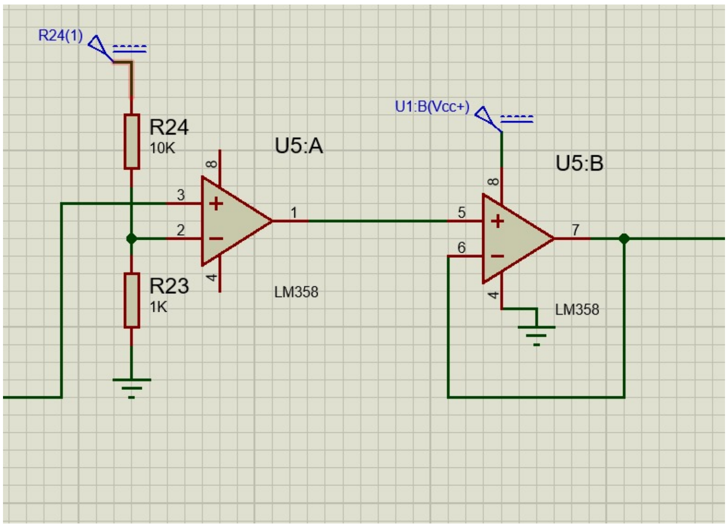
6.2 Pre-Amplifier



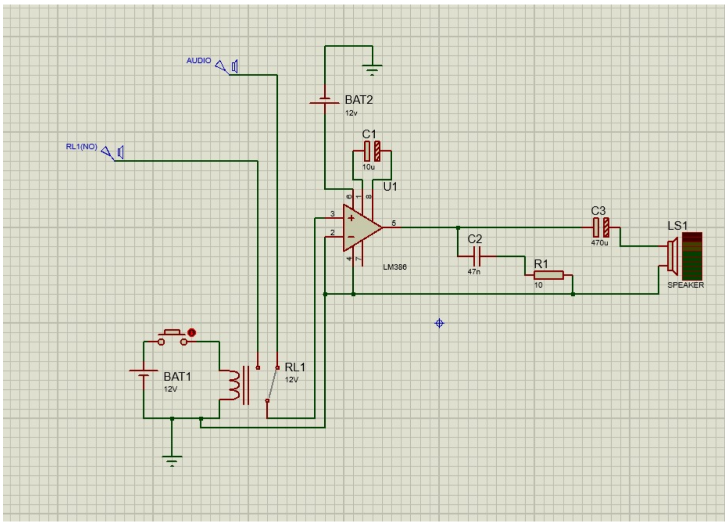
6.3 Peak Detector



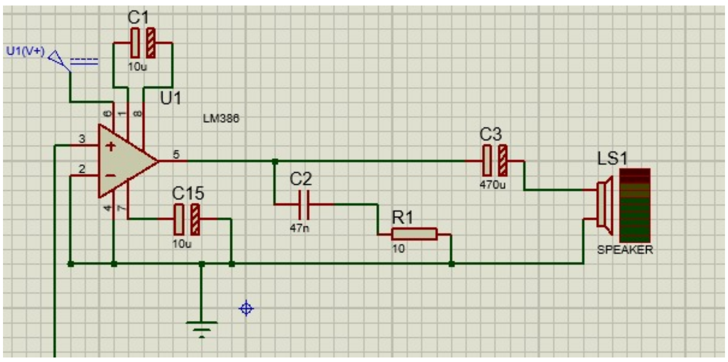
6.4 Comparator



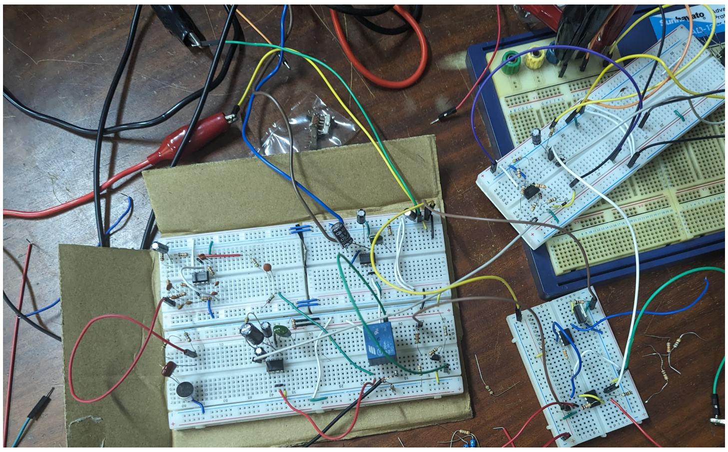
6.5 Switch

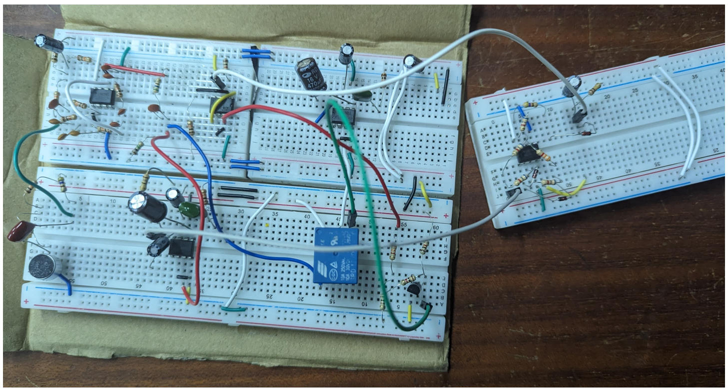


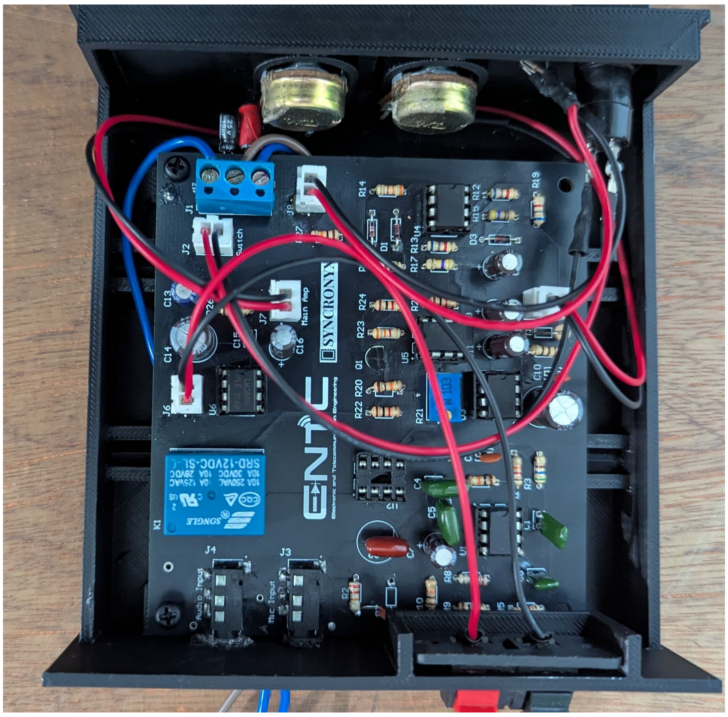
6.6 Main Amplifier



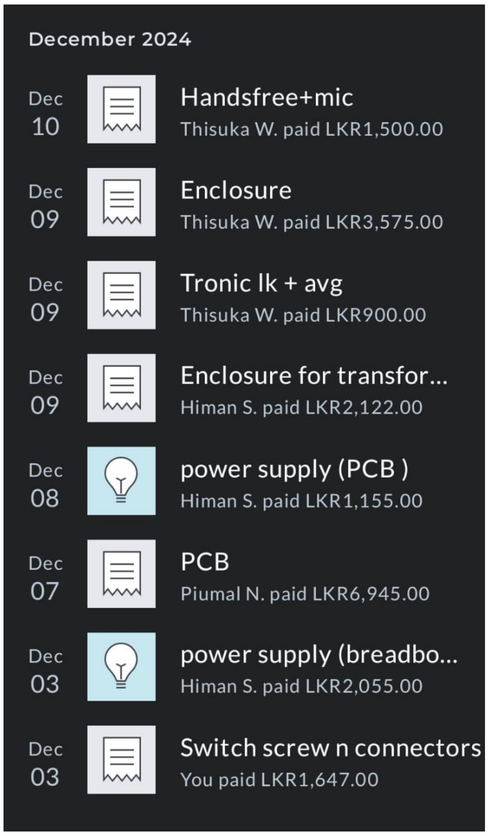
6.7 Hardware Testing







7 Bill of Materials



8 Conclusion and Future Works

Discrete analog components were used to create the analog voice-over circuit. The technology, which also has a bandpass filter for partial echo reduction, is operating without any issues. It demonstrates the design's functionality by accurately detecting the input signal and switching the channels.

Future work will incorporate the following enhancements:

- Include separate gain controls for each channel to enhance audio balance and quality.
- Adding batteries to the power circuit enhances its dependability and portability.
- Adding more channels and implementing a priority system to efficiently control the routing of signals.

The improvement will enhance the performance of the system, adaptability, and user experience.

9 Contribution of Group Members

<table>
<tr><th>Member</th><th>Contribution</th></tr>
<tr><td>Bandara I.W.T.N 220061H</td><td>Main circuit design, approach, and testing
PCB soldering
Circuit simulation and analysis
Project management</td></tr>
<tr><td>Senaweera S.A.H.D 220596C</td><td>Main circuit design, approach, and testing
Circuit simulation and analysis
Documentation</td></tr>
<tr><td>Sanjeewa P.M.G.P.N 220577U</td><td>Main circuit design, approach, and testing
Bandpass filter design
PCB design(Altium)
PCB soldering
Documentation</td></tr>
<tr><td>Wijenayaka M.B.T.I 220711D</td><td>Bandpass filter design
Enclosure design(Solidworks)</td></tr>
<tr><td colspan="2">Testing and validation shared by all members</td></tr>
</table>

Table 1: Individual Contributions

References

[1] CircuitDigest, *Audio Voice Over Circuit*, [Online]. Available: https://circuitdigest.com/electronic-circuits/audio-voice-over-circuit-using-lm386

[2] Alldatasheet.com, *LM386 Datasheet (PDF) - Unisonic Technologies*, [Online]. Available: https://www.alldatasheet.com/datasheet-pdf/pdf/413781/UTC/LM386.html

[3] Alldatasheet.com, *NE5532 Datasheet (PDF) - ON Semiconductors*, [Online]. Available: https://www.alldatasheet.com/datasheet-pdf/pdf/175241/ONSEMI/NE5532.html