Department of Electronic and Telecommunication Engineering
University of Moratuwa

Five Band Equalizer

200118X-G.I. DESHAPRIYA

This report is submitted as partial fulfilment of module EN2160.

Abstract: This is a detailed report that covers the introduction, a functional description of the system, a system model (including design parameters), a schematic, a PCB design, an enclosure design, the results of the simulation, a conclusion, and references. By varying the energy of different frequency ranges or bands, EQs are generally used to alter the frequency response of audio. A conventional graphic equalizer is made up of several audio filters or amplifiers that are each adjusted to a particular frequency in the audio spectrum. As part of this project, we developed a five band EQ that can apply a specific gain to each frequency band and show the sound level using a sound level indicator.

Contents

1 Introduction

Equalization is a fundamental and often used technique in the world of sound recording and production facilities. Using linear filters, audio equalizers let us modify various frequency ranges, giving us control over which frequencies in the audio signal should be emphasized or subdued. An equalizer's flexibility allows for modifications to the phase, tone, and several other components of the audio stream, allowing for improvement and fine-tuning.

In general, equalizers fall into two groups based on how they are implemented and work. The Graphic Equalizer falls under the first type and often comprises of many movable sliders that represent various frequency bands. Users may adjust the gain of frequency ranges using the sliders, which provides a visual depiction of the equalization curve.

The Parametric Equalizer falls into the second category and provides more detailed control over the audio signal. Users of parametric equalizers can change factors like the bandwidth (Q-factor), gain, and centre frequency for each band. Because of the ability to make precise changes, parametric equalizers are useful tools for professional audio production and processing.

1.1 Parametric Equalizer

This type of EQs offer more accuracy, they are frequently used in mixing and recording studios. They allow the user to adjust the central frequency, the bandwidth (also known as Q or quotient of change), and the frequency levels (the gain) using several knobs.

Figure 1: Parametric Equalizer

1.2 Graphic Equalizer

It includes a fixed bandwidth and middle frequency, however there are many sliders that may be used to change the gain of a particular frequency band. The more sliders are present on this EQ imply that, the more control there is over a larger spectrum of frequencies.

Figure 2: Graphic Equalizer

In this project, we'll use audio filters to create a five-band graphic equalization circuit. To separate the low, high, and mid-range frequencies of the audio stream, it will thus contain low, high, and high-pass filter circuits. Our circuits contain operational amplifier-based active filters (op-amps) and has capable of adding gains in 5 frequency bands 50Hz,250Hz,800Hz,3.3Khz, and 16Khz.

Figure 3: My Equalizer

2 Functionality Description

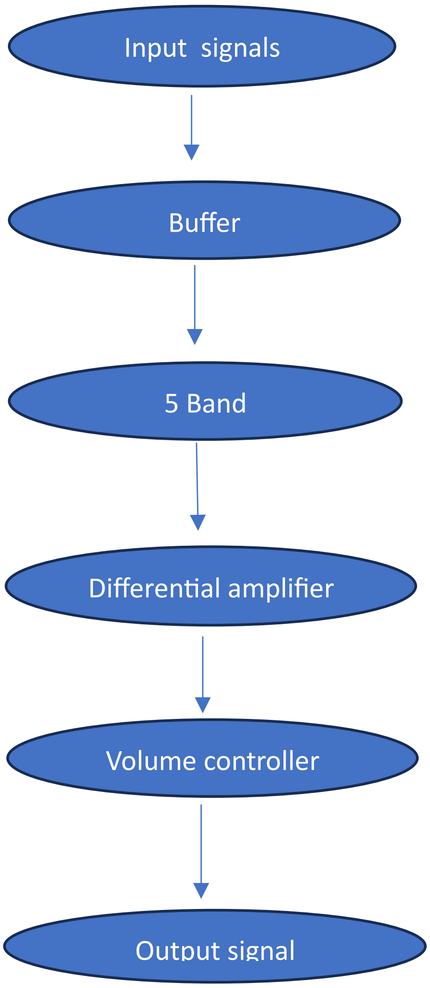


Figure 4: Functional Block Diagram

2.1 Power Supply

In this project, a 12V transformer is used to build a dual power supply that produces the Five-Band Graphic Equalizer's +12V and -12V DC voltages. Users of this equalizer have the option to modify the gain levels to alter the audio frequency response, which improves tone and clarity.

The 12V converter effectively transforms the typical 230V AC residential power source to a consistent 12V AC output to establish the dual power supply. This AC output is then rectified and filtered to provide +12V and -12V DC power, which are necessary for the equalization circuit to function properly.

Operational amplifiers and passive parts are used in the construction of the Five-Band Graphic Equalizer to allow for exact adjustment of audio signals within certain frequency ranges. For a customized listening experience, users may adjust the audio output to suit their tastes by accentuating or dilating certain frequency bands.

Safety and compatibility with the typical AC household power connection are guaranteed using the 12V transformer and dual power supplies. The equalizer can operate at peak performance thanks to its effective power management, providing a high-quality audio processing solution.

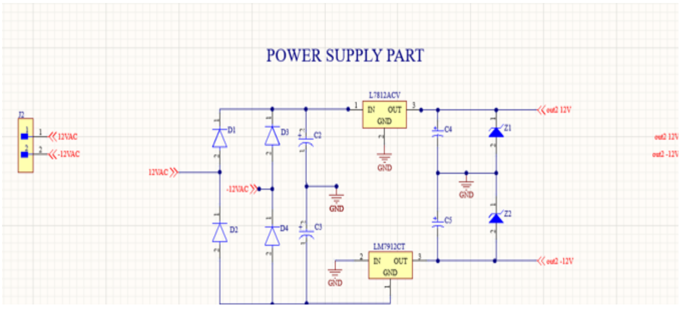


Figure 5: Power supply circuit

2.2 Input Signal

We supply the input audio signal to our circuit from smartphone through a 3.5mm audio jack cable.

Figure 6:3.5mm Audio jack

2.3 Buffer Circuit (For Circuit Isolation)

The Op-Amp Follower, or Buffer, is seen in the picture. If the voltage rails are within reach, the buffer can create an output that exactly matches the input. Therefore, at first, we could think it is pointless. However, a lot of impedance problems may be resolved using the buffer circuit. The op-amp buffer has an extremely high (near infinite) input impedance and a very low (a few ohms) output impedance. The buffer enables circuit isolation so that we may go from one to another while maintaining the voltage level without drawing current from the input signal.

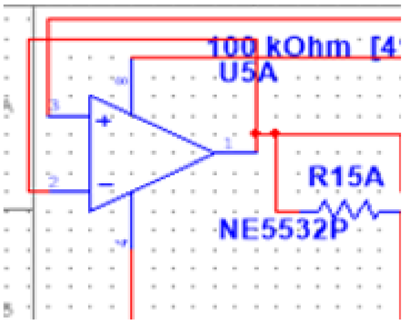


Figure 7: Buffer circuit

2.4 Differential amplifier

Differential amplifiers have ability to suppress noise. Differential noise and common-mode noise are the two main types of noise. They can simply be suppressed with an op-amp. We can consider two main reasons for common-mode noise.

1. Noise is generated in the wires and cables, due to electromagnetic induction, etc., and it causes a difference in potential (i.e., noise) between the signal source ground and the circuit ground.
2. A ground potential rise occurs when current from another circuit flows into a circuit's ground (noise). In either scenario, noise causes the ground potential, a circuit reference, to fluctuate. Common-mode noise is challenging to eliminate using conventional filters. Common-mode noise is reduced by using differential amplifiers.

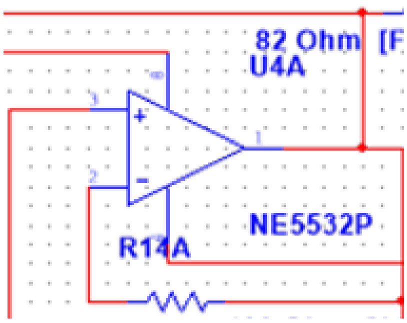


Figure 8: Differential Amplifier circuit

2.5 High Pass Filters

To let signals above a certain frequency pass through while attenuating frequencies below the cutoff, high pass filters (HPF) are crucial in audio processing. To enhance clarity and get rid of undesired low-frequency noise, they are frequently employed in audio systems.

Active high pass filters have several benefits over passive ones. Their enhanced responsiveness, which enables fine control of the cutoff frequency and slope, is one major advantage. Resonance problems in passive filters might lead to unwanted frequency peaks and distortions. Active filters, which provide improved stability and performance, successfully alleviate this issue.

Active high pass filters can also be used to regulate voltage, guaranteeing stable signal levels and a better signal-to-noise ratio. They are excellent for a variety of audio applications, such as audio equalization or audio crossover networks, due to their dependable operation and capacity to supply passband gain.

Active high pass filters' attractiveness is also increased by the small size of the components they require. Active filters have a smaller physical footprint and a simpler circuit design than passive filters since they require fewer components.

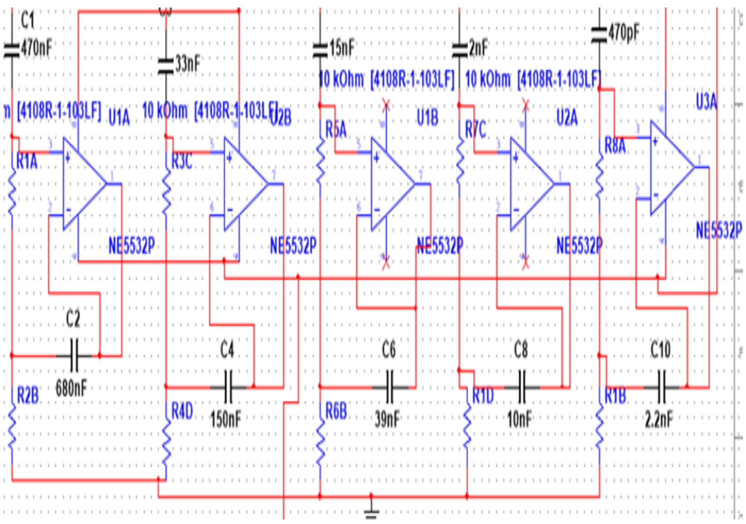


Figure 9: High pass filters

2.6 LM3915 IC Visualized Audio Level Display

In many different applications, it is commonly essential to measure the volume of audio signals. For instance, at discotheques where the volume of the music must be determined, as well as other places where the volume of the noise must be determined. One of the many ways to display the audio level of the signal is using sound pressure level meters, which solely compute the change in pressure of the sound signal. They are based on the notion that sound impulses of different frequency have pressure levels that differ. Another approach is to display the loudness of the audio signal visually. The display is frequently an array of LEDs that gradually light up to represent the audio stream's loudness.

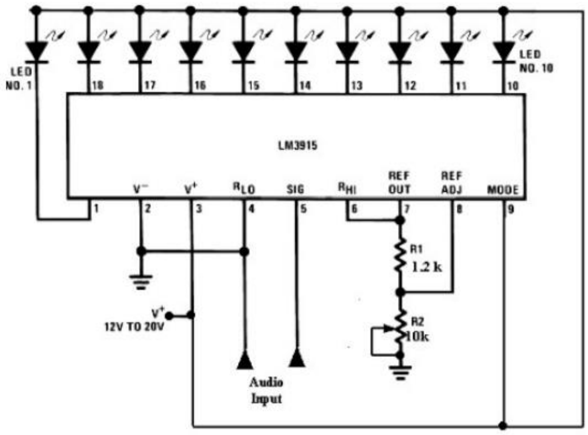


Figure 10: *LM3915 as an Audio Level Meter*

2.6.1 LM3915

The LM3915 is a dot/bar display driver that uses the analog input to control several LEDs. In essence, it drives each neighbouring LED in a logarithmic manner, in 3DB steps. It runs on a supply voltage range of 3 to 25 volts. Pins 1, 10, and 18: The 3V to 20V supply is linked to the output LEDs' anodes. Pin 2: Usually linked to the ground, this pin is the negative analog voltage source. Pin 3: This pin serves as the positive voltage source and typically ranges from 3 to 20 volts. pin4: Typically, grounded is pin number four. Pin 5: The audio signal input goes to this pin, which serves as the signal input pin. A short exists between pins 6 and 7. Each LED draws its own current based on the current flowing through pin 7. Pin 8: It is used to change the reference voltage. Pins 7 and 8 are connected by a resistance of 1.2 kohms, resulting in a 1.25-volt difference between them. To change the reference voltage, a potential divider is attached to the resistor. Pin 9: This pin, designated as the mode selector, is used to choose between the dot mode and the bar mode. The pin is directly linked to pin 3 for the bar mode, or the positive voltage supply. The pin is left unconnected and open for dot mode.

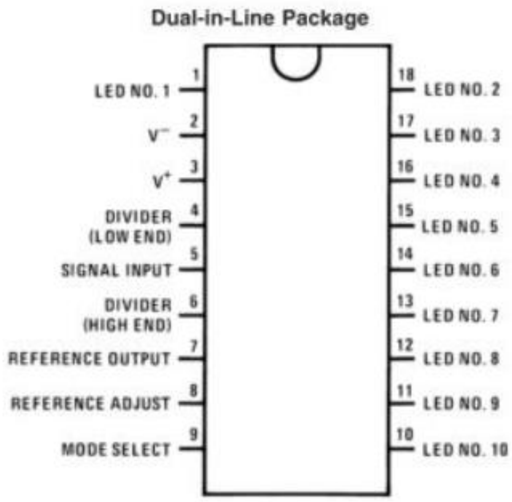


Figure 11: *LM3915*

2.7 Audio Amplifier

To improve the effectiveness of our Five-Band Graphic Equalizer in this project, we included an audio amplifier. Due to its ease of use, effectiveness, and widespread use in audio applications, the LM386 audio amplifier IC was chosen for this application.

The audio amplifier is an accessory with numerous uses. First off, it makes sure that the equalized audio signals continue to be strong enough and clear enough to drive a variety of audio output devices, including speakers or headphones, without fidelity loss. The LM386 provides dependable amplification while keeping the circuitry small and reasonably priced thanks to its low distortion and high gain characteristics.

The audio amplifier also enhances the entire user experience by increasing audio output, which makes listening more immersive and interesting. Users may enjoy their preferred music or audio content at higher volumes and with a wider dynamic range thanks to it.

The Five-Band Graphic Equalizer circuit's incorporation of the LM386 audio amplifier enhances the audio signals once they have been precisely sculpted using the adjustable frequency bands, adding to the equalizer's utility. By combining equalization and amplification, a well-rounded and pleasurable audio output that considers personal tastes is produced.

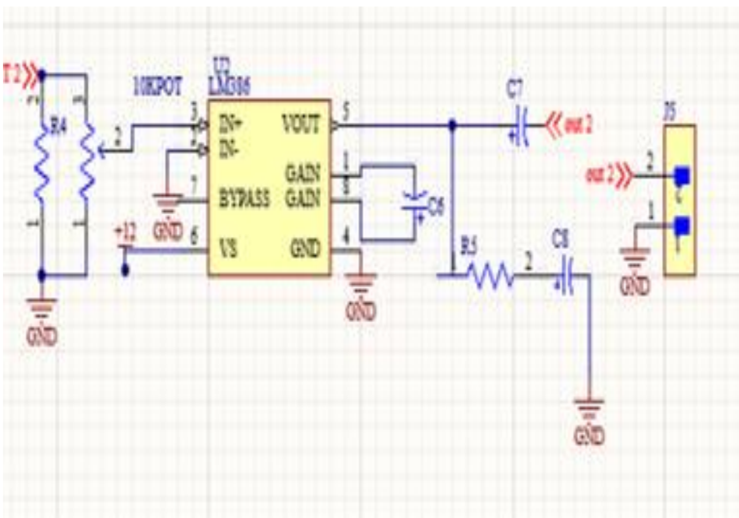


Figure 12: Audio Amplifier

2.7.1 LM386

A popular audio power amplifier IC noted for its simplicity and effectiveness is the LM386. It has a supply voltage range of 4V to 12V, has gain control, and has a maximum power output of about 700mW with an 8-ohm load at a 9V supply. It is adaptable in audio circuits thanks to its low input impedance, which makes interacting with various audio sources simple. A bypass capacitor is used to reduce oscillation and noise. The LM386 is a well-liked option for many audio amplification applications because to its small size, low power consumption, and adjustable gain control, including its incorporation into the Five-Band Graphic Equalizer in this project.

Figure 12: LM386

3 System model (with design parameters)

In my project, I have developed a Five-Band Graphic Equalizer with Active High Pass Filters. The system model incorporates the design parameters essential for achieving precise audio frequency response control. The equalizer features five frequency bands at 50Hz, 250Hz, 800Hz, 3.3kHz, and 16kHz, each created using active high pass filters with the NE5532 operational amplifier. Users can adjust gain within the range of -12dB to +12dB for each band, allowing customization of audio tonal balance. Additionally, a sound level indicator is included to provide real-time audio intensity visualization. This comprehensive system model ensures a versatile and efficient audio processing solution, meeting the requirements of audio enthusiasts and professionals alike.

Using the TL072 operational amplifier IC, I prototyped the Five-Band Graphic Equalizer in the early phases of our project. The TL072, which has high input impedance and low noise, makes it suited for audio applications, therefore it served as an excellent starting point for testing and confirming the equalizer's operation.

I chose to switch to the NE5532 operational amplifier IC for the final PCB design after a successful prototype and performance study. The NE5532 is the perfect option for audio processing because to increased performance attributes including lower distortion and a higher signal-to-noise ratio.

We chose to switch to the NE5532 operational amplifier IC for the final PCB design after a successful prototype and performance study. The NE5532 is the perfect option for audio processing because to increased performance attributes including lower distortion and a higher signal-to-noise ratio.

The Five-Band Graphic Equalizer's overall performance was improved, and audio quality was increased because to the switch to the NE5532 for the PCB design. Our choice was heavily influenced by its capacity to handle a wide variety of frequencies as well as its track record of dependability and stability in audio circuits.

By incorporating the NE5532 IC into the final PCB design, we aimed to deliver a professional-grade audio equalizer with superior sound quality and precise frequency response control. This optimized choice for the operational amplifier ensures that our Five-Band Graphic Equalizer meets the expectations of audio enthusiasts and professionals, providing them with an efficient and powerful audio processing tool.

3.1 NE5532 Vs TL072

Operational amplifier integrated circuits (ICs) like the NE5532 and TL072 are often employed in audio and signal processing applications. While there are some similarities between them, they also have unique qualities that make them more suitable for particular use situations. Compare the two ICs now:

NE5532:

- Low Noise: The NE5532 is known for its low noise performance, making it ideal for audio applications where signal clarity is crucial.
- High Slew Rate: It has a high slew rate, allowing it to respond quickly to rapid changes in the input signal.
- Wide Bandwidth: The NE5532 offers a wide bandwidth, enabling it to handle a broad range of frequencies accurately.
- Dual Op-Amp: The NE5532 comes in a dual op-amp package, providing two independent op-amps in a single IC.
- Audio Applications: Its low noise and high performance make it well-suited for audio processing tasks, such as audio mixing, equalization, and headphone amplifiers.

Figure 13: NE5532

TL072:

- Low Input Bias Current: The TL072 features low input bias current, making it suitable for applications where low current flow into the input terminals is critical.
- Low Power Consumption: It has relatively low power consumption, making it suitable for battery-operated or low-power applications.
- General-Purpose Op-Amp: The TL072 is a general-purpose op-amp, commonly used in various applications, including audio, signal conditioning, and instrumentation.
- Dual Op-Amp: Like the NE5532, the TL072 also comes in a dual op-amp package, offering two op-amps in one IC.

Figure 14: TL072

3.2 Active high pass filter

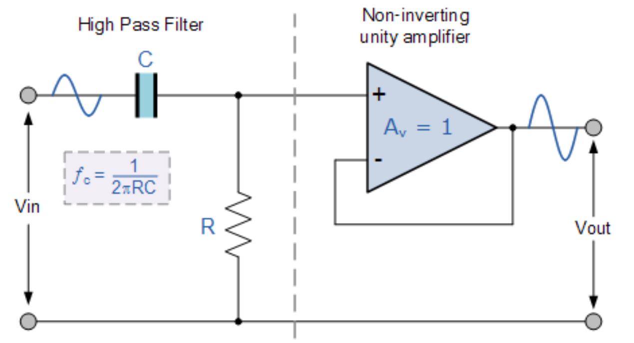


Figure 15: First order high pass filter

An active high pass filter is theoretically impossible. Active high pass filters appear to be band pass filters with a high frequency cut-off that is determined by the choice of op-amp and gain, in contrast to passive high pass filters that have a "infinite" frequency response. This is because the maximum pass band frequency response of an active high pass filter is constrained by the open-loop characteristics or bandwidth of the operational amplifier being used.

In the Operational Amplifier tutorial we saw that the maximum frequency response of an op-amp is limited to the Gain/Bandwidth product or open loop voltage gain (A V) of the operational amplifier being used giving it a bandwidth limitation, where the closed loop response of the op amp intersects the open loop response.

A commonly available operational amplifier such as the uA741 has a typical "open-loop" (without any feedback) DC voltage gain of about 100dB maximum reducing at a roll off rate of -20dB/Decade (-6db/Octave) as the input frequency increases. The gain of the uA741 reduces until it reaches unity gain, (0dB) or its "transition frequency" (ft) which is about 1MHz. This causes the op-amp to have a frequency response curve very similar to that of a first-order low pass filter and this is shown below.

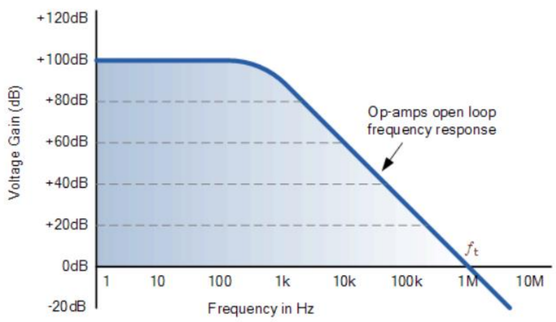


Figure 16: Curve of a typical operational amplifier's frequency response

As implied by its name, a first order (single pole) Active High Pass Filter attenuates low frequencies while passing high frequency signals. It only consists of a passive filter portion followed by an operational amplifier that does not invert. The circuit's frequency response is identical to that of a passive filter, with the exception that the gain of the amplifier boosts the signal's amplitude. For a non-inverting amplifier, the pass band voltage gain is equal to 1 + R2/R1, just like in a low pass filter circuit.

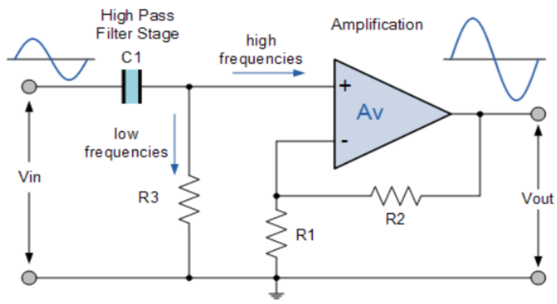


Figure 15: Active High Pass Filter with Amplification

This first-order high pass filter consists simply of a passive filter followed by a non-inverting amplifier. The frequency response of the circuit is the same as that of the passive filter, except that the amplitude of the signal is increased by the gain of the amplifier.

For a non-inverting amplifier circuit, the magnitude of the voltage gain for the filter is given as a function of the feedback resistor (R2) divided by its corresponding input resistor (R1) value and is given as:

Gain for an active HPF:

$$\text{Voltage Gain, (Av)} = \frac{Vout}{Vin} = \frac{A_F\left(\frac{f}{fc}\right)}{\sqrt{1+\left(\frac{f}{fc}\right)^2}}$$

Where:

- A_F = the Pass band Gain of the filter, (1 + R2/R1)
- f = the Frequency of the Input Signal in Hertz, (Hz)
- fc = the Cut-off Frequency in Hertz, (Hz)

Just like the low pass filter, the operation of a high pass active filter can be verified from the frequency gain equation above as:

- At very low frequencies, $f < fc$ $$\frac{Vout}{Vin} < A_F$$
- At the cut-off frequency, $f = fc$ $$\frac{Vout}{Vin} = \frac{A_F}{\sqrt{2}} = 0.707\,A_F$$
- At very high frequencies, $f > fc$ $$\frac{Vout}{Vin} \cong A_F$$

Then, the **Active High Pass Filter** has a gain A_F that increases from 0Hz to the low frequency cut-off point, f_C at 20dB/decade as the frequency increases. At f_C the gain is $0.707*A_F$, and after f_C all frequencies are pass band frequencies, so the filter has a constant gain A_F with the highest frequency being determined by the closed loop bandwidth of the op-amp. When dealing with filter circuits the magnitude of the pass band gain of the circuit is generally expressed in decibels or dB as a function of the voltage gain, and this is defined as:

Magnitude of Voltage Gain in (dB):

$$Av(dB) = 20\log_{10}\left(\frac{Vout}{Vin}\right)$$

$$\therefore\ -3dB = 20\log_{10}\left(0.707\frac{Vout}{Vin}\right)$$

For a first order filter the frequency response curve of the filter increases by 20dB/decade or 6dB/octave up to the determined cut-off frequency point which is always at -3dB below the maximum gain value. As with the previous filter circuits, the lower cut-off or corner frequency (fc) can be found by using the same formula:

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

The corresponding phase angle or phase shift of the output signal is the same as that given for the passive RC filter and **leads** that of the input signal. It is equal to **+45°** at the cut-off frequency fc value and is given as:

$$Phase\ Shift\ \phi = tan^{-1}\left(\frac{1}{2\pi fRC}\right)$$

A simple first-order active high pass filter can also be made using an inverting operational amplifier configuration as well, and an example of this circuit design is given along with its corresponding frequency response curve. A gain of 40dB has been assumed for the circuit.

I have added a novel feature by using 50K potentiometers to change the resistor values in the active high pass filters in my five-band graphic equalizer circuit. Due to this design decision, users may dynamically alter the gain and cutoff frequency of each frequency band, allowing for in-the-moment frequency response customisation.

Users may accurately alter the resistance of the active high pass filters by using 50K potentiometers, which will change the cutoff frequency of the filter for each band. This feature gives customers more freedom to customize the tonal balance of the audio output to match their tastes and unique audio needs.

The use of potentiometers in the active high pass filters adds interactivity to our Five-Band Graphic Equalizer, providing a user-friendly interface for on-the-fly adjustments. As users turn the potentiometers, they can observe the immediate impact on the frequency response, making it easier to fine-tune the audio output to their liking.

Furthermore, this design choice allows for experimentation and exploration of different frequency responses, making the equalizer a versatile tool for audio enthusiasts and professionals alike. Users can create unique sound signatures by adjusting the resistor values with ease, enabling them to achieve a customized audio experience.

Figure 16: 50KOhm potentiometers

4 Final Schematic

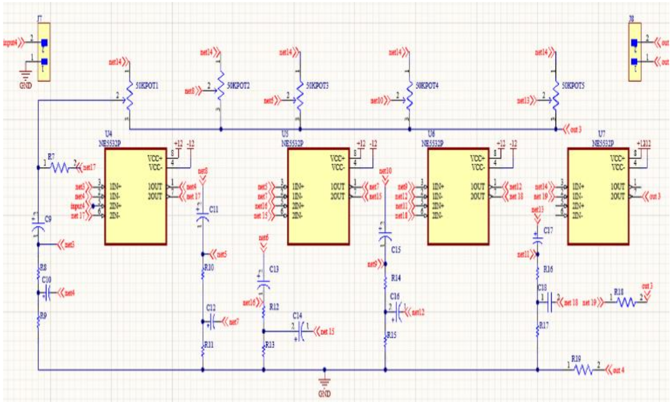


Figure 17: Main circuit

We have considered the following points to get maximum audio performance.

- Regulated power supply circuit
- Use metal film type of resistor
- Use MKM type of nonpolar capacitor
- Use tantalum type of bipolar capacitor (electrolytic capacitor)

Typically, equalizer circuits partition the audio spectrum into distinct frequency bands, with independent gain controls for each band. An audio power amplifier receives the combined output of each band at IC4(A). Avoiding overlap in neighbouring bands is necessary since doing so produces coloration into the audio stream. A suitable quality factor (Q) must be used. As the filters are highly sensitive and for best performance, the resistors should be metal-film type and the capacitors should be polyester type.

Figure 17: Tantalum type of bipolar capacitor

Figure 18: MKM type of nonpolar capacitor

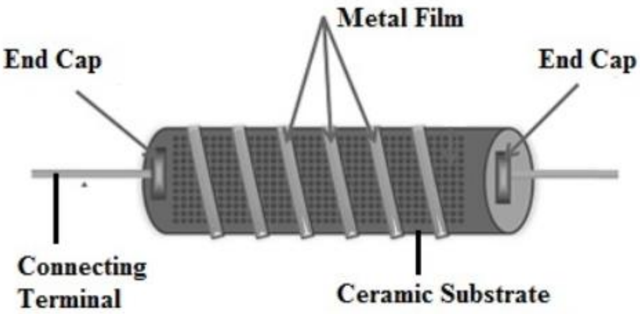


Figure 19: metal film type of resistor

5.1 The Equalizer Circuits

The proposed equalizer is a 5-band circuit, the cut-off frequencies are at: 50Hz, 250Hz, 800Hz, 3.3kHz, 16kHz.I used NE5532 the 5 filters. (Figure 17)

5.2 The Power Supply

Use a centre-tapped transformer to convert 230V AC mains into two 12V DC power supplies. The two secondary windings should be rectified using full-wave bridge rectifiers. After that, use voltage regulators to control the rectified outputs to produce steady DC voltages of +12V and -12V for IC applications.

Figure 21: centre-tapped transformer

5 PCB Design

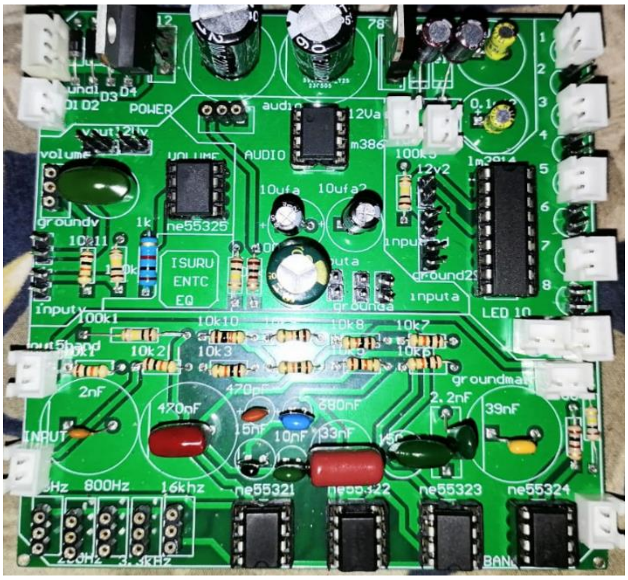


Figure 20: PCB

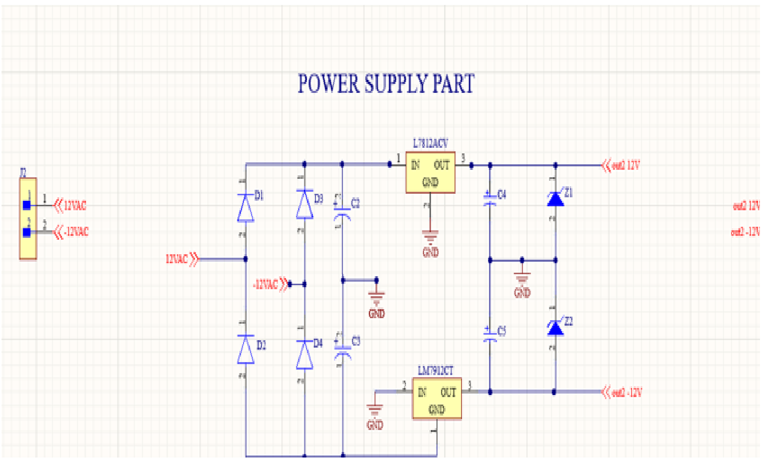


Figure 22: Power supply circuit

The goal was to change the 230V AC mains voltage into steady, controlled DC voltages so that delicate electronic components would operate effectively and consistently. A centre-tapped transformer steps down the mains voltage, full-wave bridge rectifiers turn the AC voltage into pulsing DC, and filter capacitors reduce ripple in the power supply circuit. Voltage regulators models 7812 and 7912 are used to produce exact and reliable DC outputs of +12V and -12V, respectively. The circuit's efficiency, voltage control, and thermal performance were all verified by thorough testing. A range of IC applications may now be powered by the same power supply, enhancing the usefulness and performance of electronic systems.

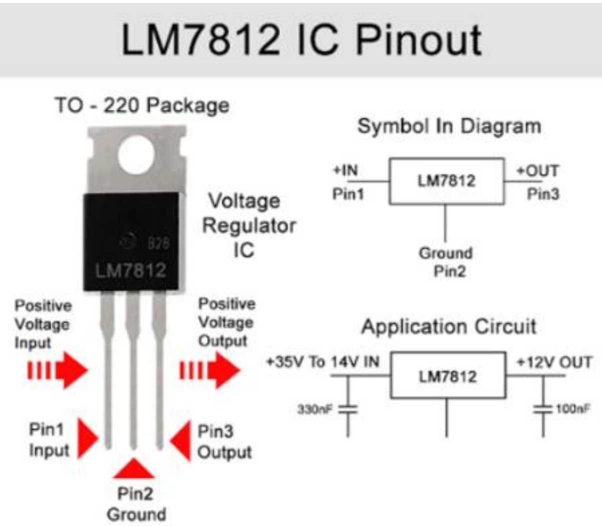


Figure 23: L7812

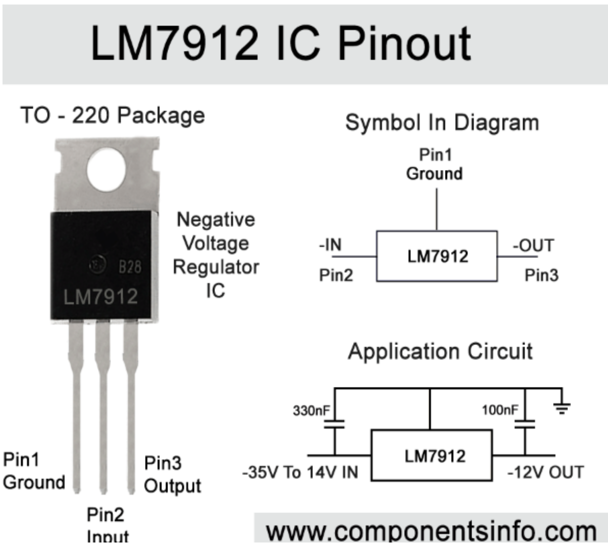


Figure 24: L7912

6 Enclosure Design

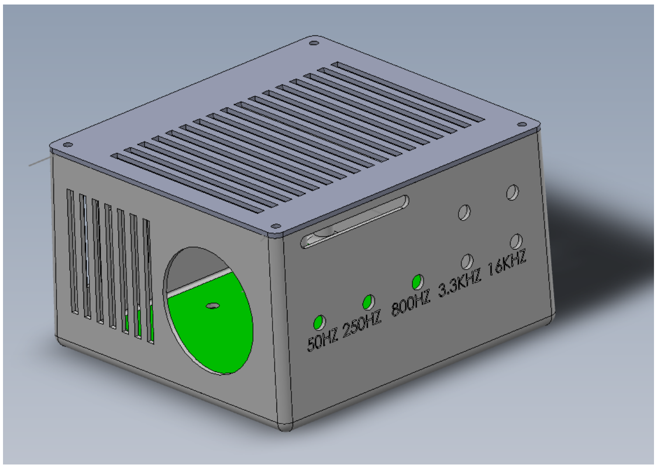


Figure 25: Enclosure Design

6.1 About this product

EQ Band Centre Frequencies: 50 Hz, 250 Hz, 800Hz, 3.3 kHz, 16 kHz allowed for flexible aux volume adjustment, each with a different Frequency control. A 12V DC power supply is used to operate this audio equalizer. To measure the level of the audio signal, our circuit used LM3915. The LM3915 is a dot/bar display driver that utilizes the analog input to operate a group of LEDs.

6.2 Product Specifications

- Input voltage-230V/50Hz (AC)
- Opamp supply voltage -15V and -15V
- LED- use 10 LEDs.
- Frequency bands -50Hz ,200Hz, 800Hz, 3300Hz, 16000Hz
- LM3914- Use for LED indicator circuit
- LM386 -Use for audio amplifier circuit
- Enclosure Material -PLA
- Product Dimensions -100mm *100mm *40mm (May change depending on the design requirements)

7 Simulation Results

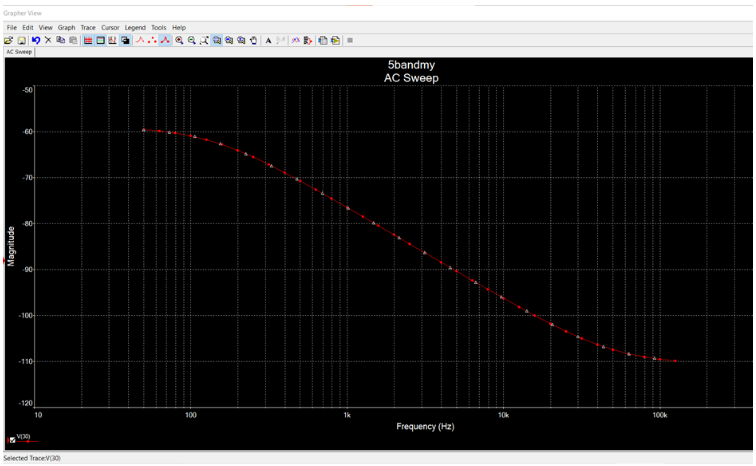


Figure 26:The frequency Vs magnitude digram when all Potentiometer are not use

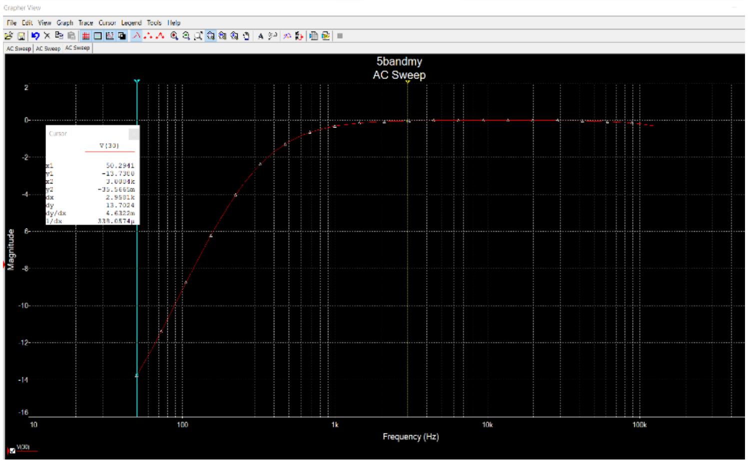


Figure 27: If first Potentiometer (left side in the diagram) are used and others are not used.

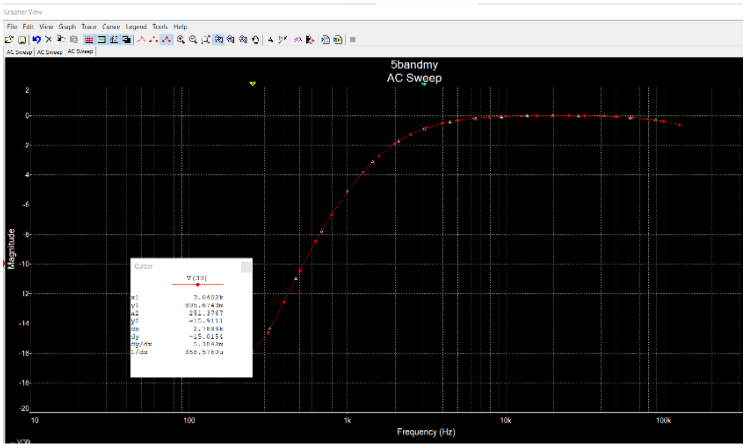


Figure28: If first and second Potentiometers are used and others are not used

Now we can see under 250Hz (low frequency) are removed.

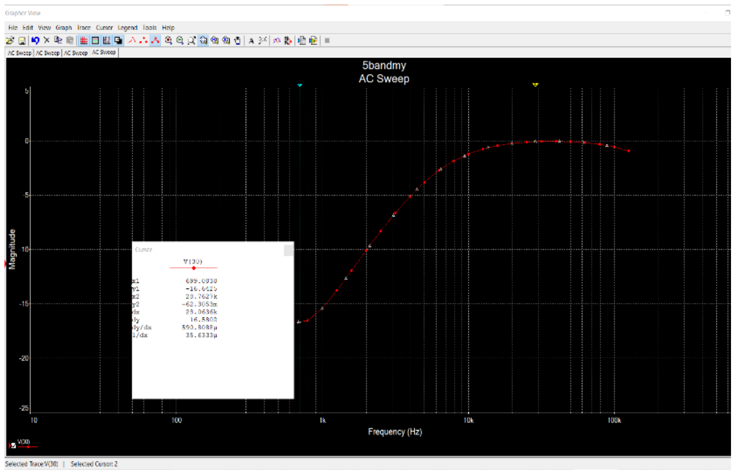


Figure 29: If 1,2,3 Potentiometers are used others are not used.

We can see under 700Hz low frequency are removed.

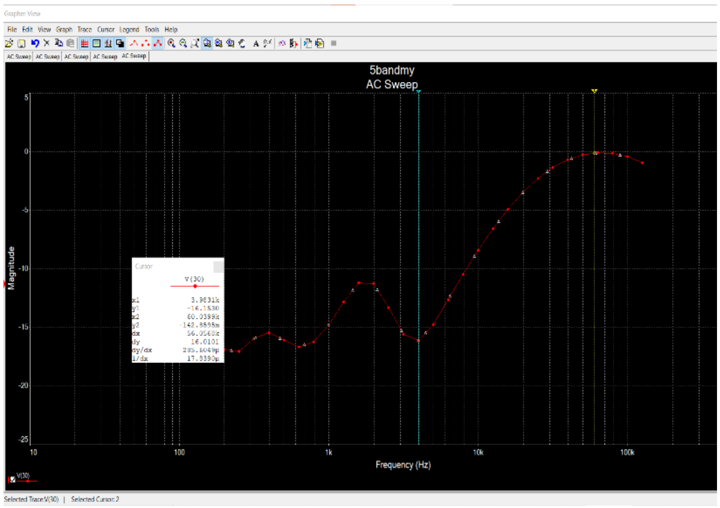


Figure 30: If 1,2,3 and 4 Potentiometers are used others are not used.

We can see under 4KHz low frequency are removed.

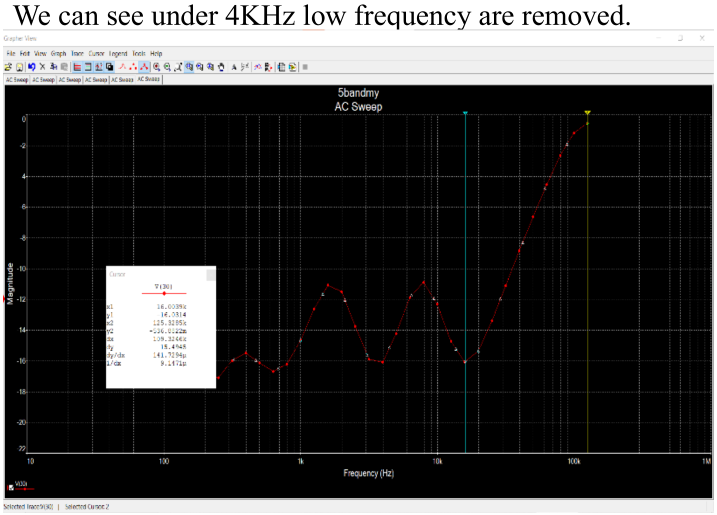


Figure 31: If all Potentiometers are used,

We can see under 16KHz low frequency are removed.

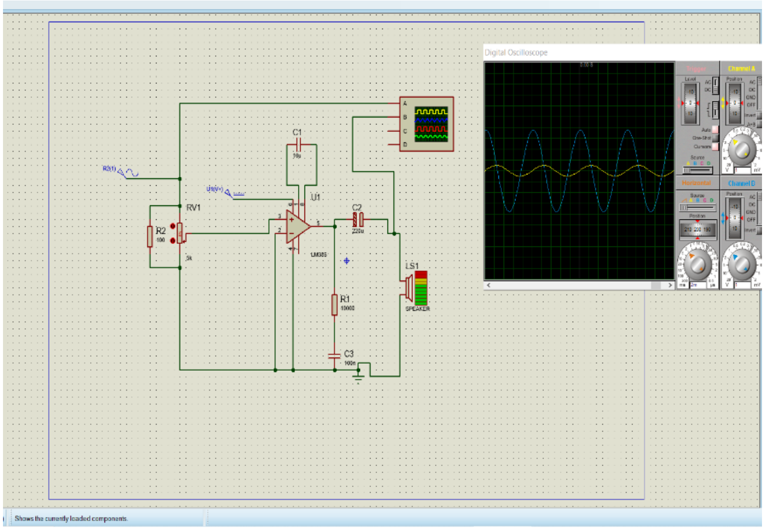


Figure 32: Audio amplifier part

7.1 Volume controller

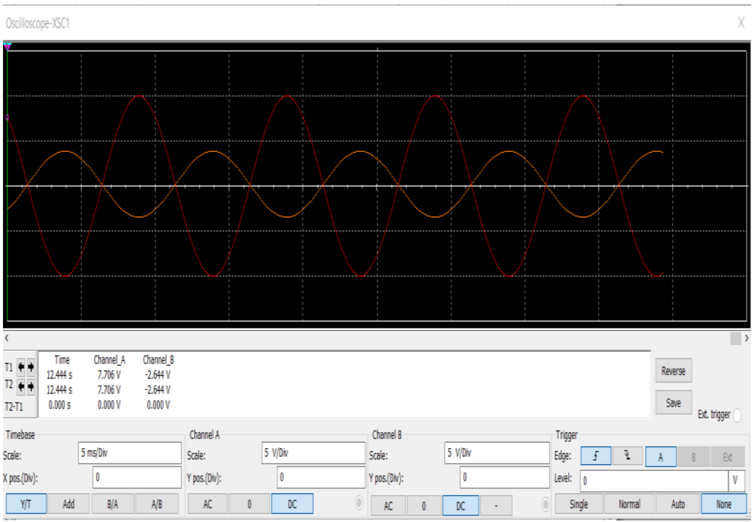


Figure 33: Voluem controller part

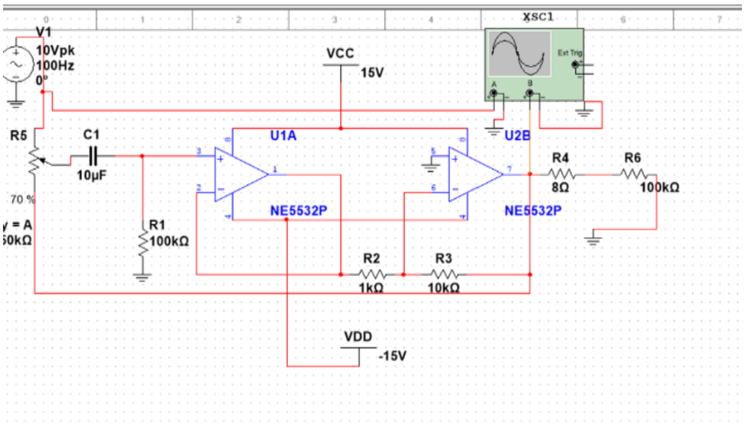


Figure 34. Volume controller circuite

The user's control is further increased by including a volume controller circuit in this configuration. Users may change the audio's overall loudness using the volume control, raising or lowering the output volume without changing the equalizer's frequency balance. This adaptability is especially helpful when listening to diverse sorts of material, such as music, movies, or games, or when utilizing high-quality headphones or external speakers.A 5-band equalization and a volume controller circuit can also work together to account for differences in audio quality across various sources.

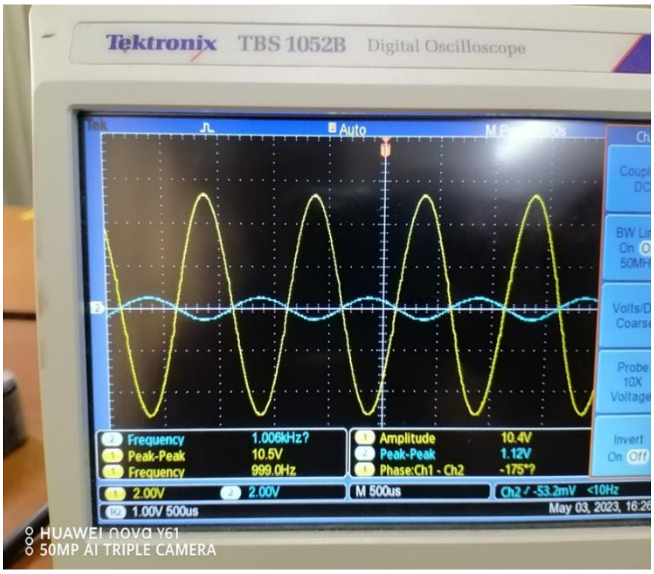


Figure 35.1: Volume controller oscilloscope results

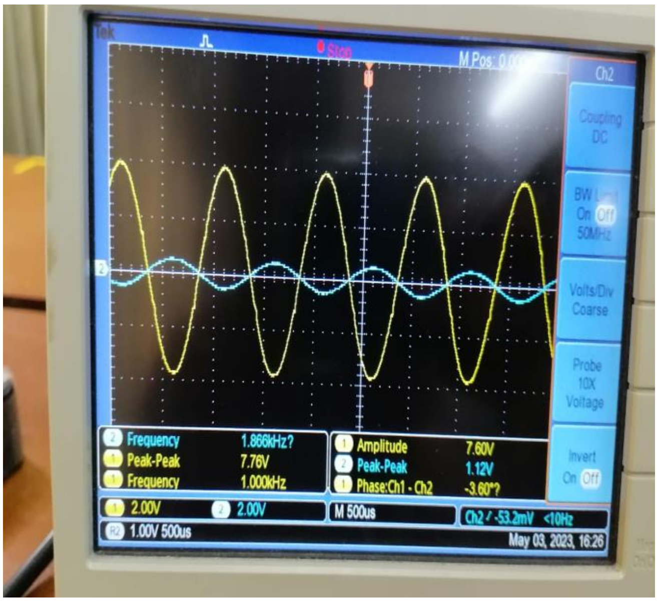


Figure 35.2: Volume controller oscilloscope results

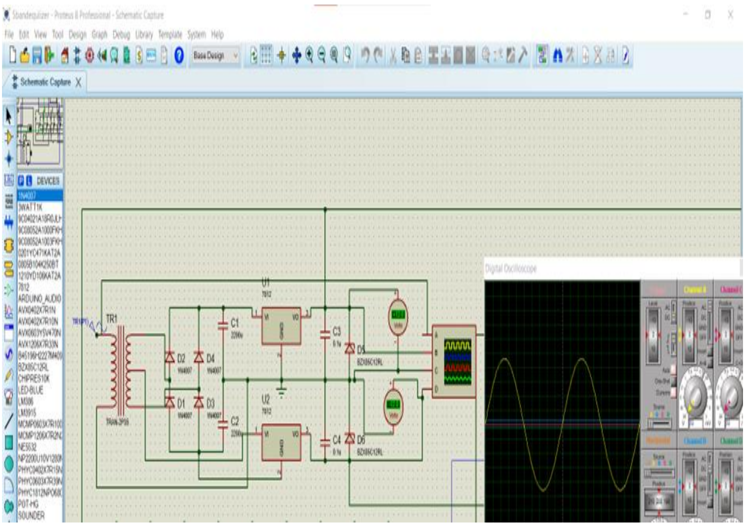


Figure 36:Power supply part

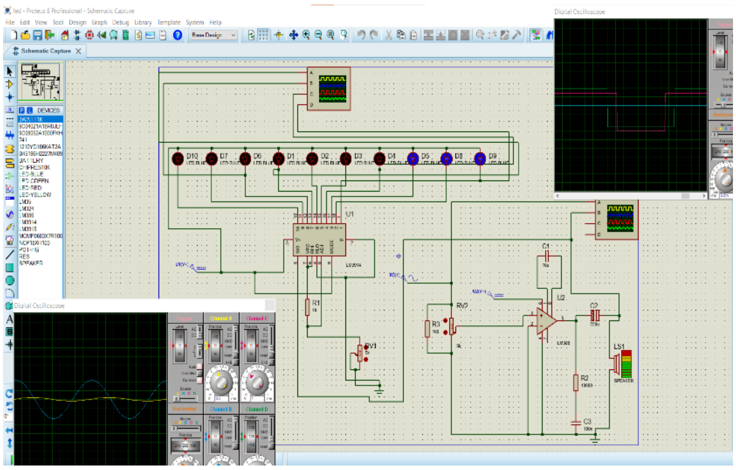


Figure 37: Led indicator's part.

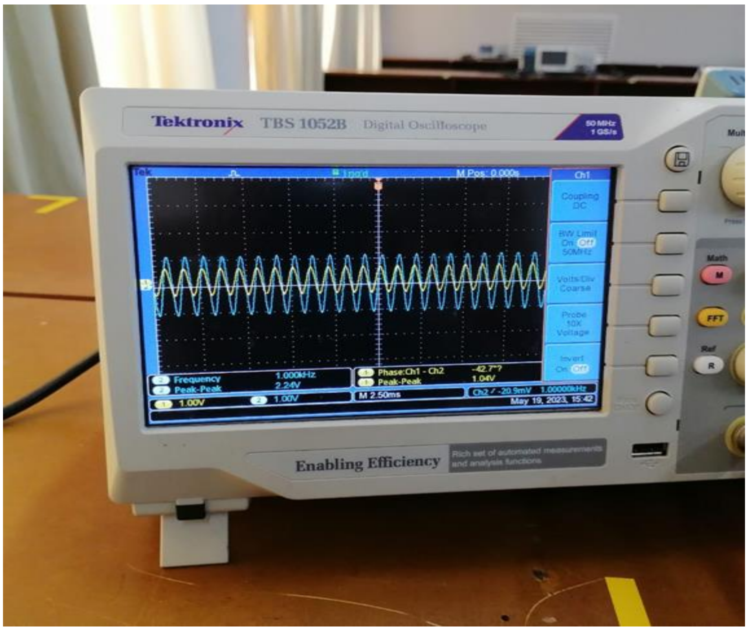


Figure 38.1: Some oscilloscopes result each band.

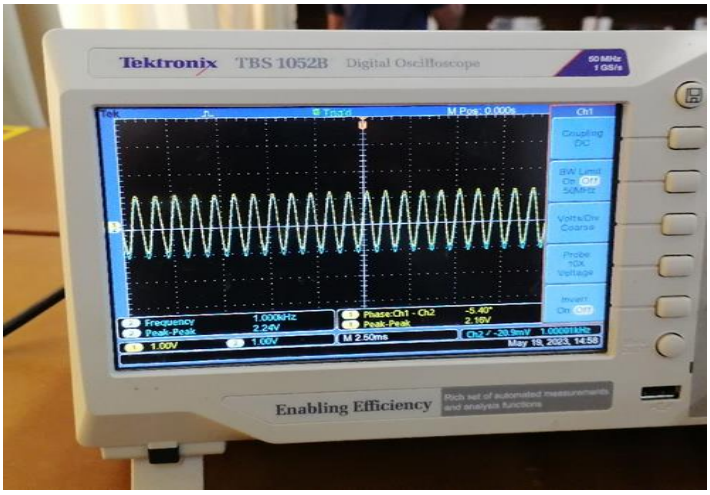


Figure 38.2: Some oscilloscopes result each band.

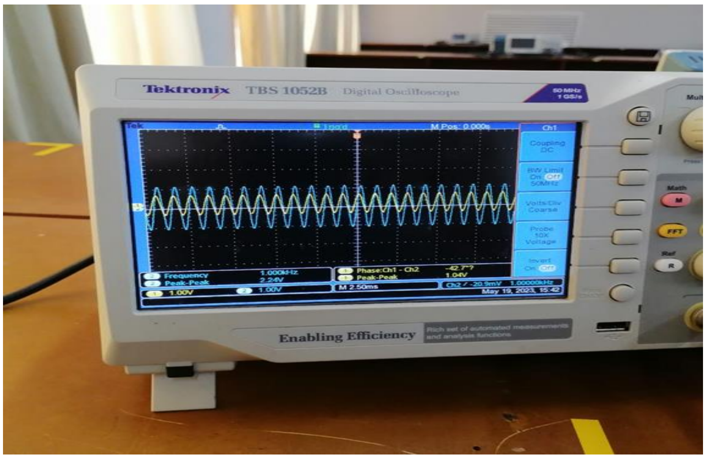


Figure 38.3: Some oscilloscopes result each band.

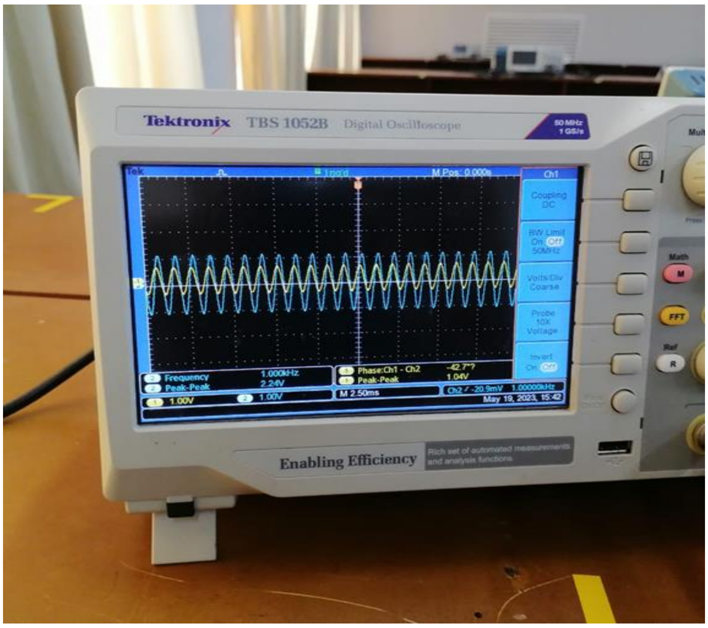


Figure 38.4: Some oscilloscopes result each band.

8 Instructions for assembly and how use product

This product has 2 parts. These two parts I mention in below figure (39). These parts can assembly using 3.5mm 4 screws.

Figure 39: Product parts

Box Top

Figure 39: 5 band Knobs

These knobs use to adjust the 5 bands.

Figure 40: volume and audio Knobs

This Knob use to adjust the audio amplifier.

This Knob use to adjust the overall volume of the product.

Figure 41: switches and output port

This is output port.

This switch use to on and off this product.

This switch use to off all LED s.

Figure 42: LED indicators

Led indicators.

Figure 43: Product

Input-3.5mm audio jack speaker Plug

9 Extra features

This project includes an audio amplifier circuit that was intended to enable volume control in addition to the five-band visual equalizer. The audio signal was amplified by the amplifier circuit using a typical op-amp architecture, and the volume level was controlled by a potentiometer. The amplifier circuit and volume control were combined, making it simple to change the output level. After that, the equalizer and amplifier circuits were combined to provide a comprehensive audio processing system that enables both fine-tuned frequency response changes through the equalization and overall volume control through the amplifier. These elements work together to create a highly flexible and adaptable audio processing system appropriate for a variety of applications.

An LED indicator circuit to show the audio level was also included in this project. To offer a precise visual representation of the audio level and make it simple for the user to monitor and control the volume level, the LED circuit was integrated into the amplifier circuit. The LED circuit is a useful addition to the audio processing system since it gives the user a simple and informative interface.

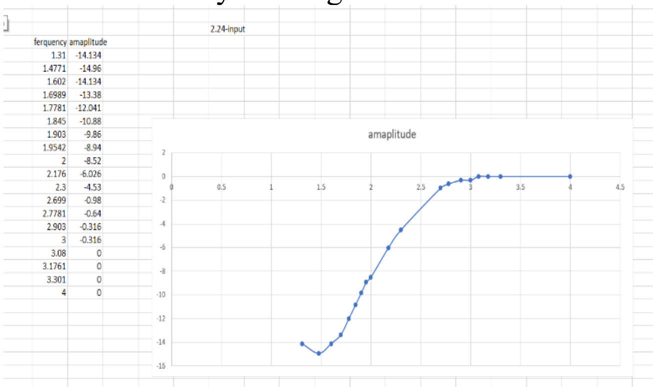
Figure 44: LED indicators

10 How to test for functionally

To make sure the 5-band audio equalizer works as planned and successfully adjusts audio signals throughout the designated frequency bands, it is crucial to test its operation. An oscilloscope was used as a helpful instrument to thoroughly assess the equalizer's performance for this purpose. The audio signals before and after equalization may be shown accurately visually thanks to the oscilloscope. A common audio input stream with a specified frequency range was fed into the equalization to perform the functionality testing. The equalizer's output was then linked to the oscilloscope to record the altered audio stream. The behaviour of the signal at various frequencies was evaluated by separately testing each band of the equalizer by varying its strength. The oscilloscope showed waveforms that represented the frequency and amplitude of the audio signal during the test. Any gain or attenuation differences caused by the equalizer might be easily found by carefully examining the waveforms. The oscilloscope also made it easier to find any possible phase shifts or distortions that could have happened during the equalization procedure.

The measured findings were contrasted with the anticipated theoretical response for each frequency band to confirm the correctness of the equalizer's operation. Any variations from the predicted behaviour were carefully examined and recorded for additional investigation. Additionally, the oscilloscope enabled for real-time audio signal monitoring, allowing for dynamic equalization setting tweaks to see changes in the waveform immediately. This feature was very helpful for optimizing audio enhancement and fine-tuning the equalizer's effectiveness.

The 5-band audio equalizer's high-pass filter was evaluated using oscilloscope waveform analysis. We changed the frequency of the input signal and measured the amplitude of the matching output waveform. The frequency vs. magnitude plot we produced using the data showed how the filter behaved by attenuating lower frequencies while allowing higher frequencies to pass through almost unaltered. The high-pass filter's operation and capacity to adhere to the required standards were validated by the diagram.



ferquency	amaplitude
1.31	-14.134
1.4771	-14.96
1.602	-14.134
1.6989	-13.38
1.7781	-12.041
1.845	-10.88
1.903	-9.86
1.9542	-8.94
2	-8.52
2.176	-6.026
2.3	-4.53
2.699	-0.98
2.7781	-0.64
2.903	-0.316
3	-0.316
3.08	0
3.1761	0
3.301	0
4	0

Figure 45: Test for filters

11 Conclusion and future works

In contrast to existing current-controlled equalizers, the authors of this work describe an active equalizer that offers a streamlined approach to audio equalization and has a quick balancing speed. 50Hz, 250Hz, 800Hz, 3.3KHz, and 16KHz are among the five unique frequency bands that the suggested equalizer is intended to increase gains in. The power supply, audio source, buffer, differential amplifier, band-pass filters, controller, and volume controller are put together to make the equalization circuit.

This design does not rely on batteries to balance signals, in contrast to conventional equalizers that do. To convert to DC and power the equalization process, it instead depends on a 230VAC power source. High energy transfer efficiency, rapid balancing, and user safety are the equalizer's major goals. An important factor in balancing speed determination is the balancing current. The Voltage-Off Time (VOT) technique and the Voltage-Ratio technique (VRM) are two strategies that the authors suggest and use to address the problem of lowering balancing current during the later phases of equalization.

This design does not rely on batteries to balance signals, in contrast to conventional equalizers that do. To convert to DC and power the equalization process, it instead depends on a 230VAC power source. High energy transfer efficiency, rapid balancing, and user safety are the equalizer's major goals. An important factor in balancing speed determination is the balancing current. The Voltage-Off Time (VOT) technique and the Voltage-Ratio technique (VRM) are two strategies that the authors suggest and use to address the problem of lowering balancing current during the later phases of equalization.

To overcome this limitation, the authors propose a method to adjust the balancing current intensity in accordance with the battery's voltage. By calculating the average current from the battery when the main switch is on, based on the inductor current summed over one switching period, the duration of the conduction state can be varied to adjust the balancing current.

In conclusion, this work presents an active equalizer that does not require batteries and can offer adjustable gains in five frequency bands. The equalizer provides quicker balancing and higher energy transfer efficiency by utilizing cutting-edge techniques like the VOT and VRM methodologies. This concept, powered by a 230VAC to DC converter, provides audio fans looking to fine-tune their music experience across numerous frequency bands with a useful and effective option.

12 Appendices

12.1 Appendix A - Product

Figure 46: Final Product

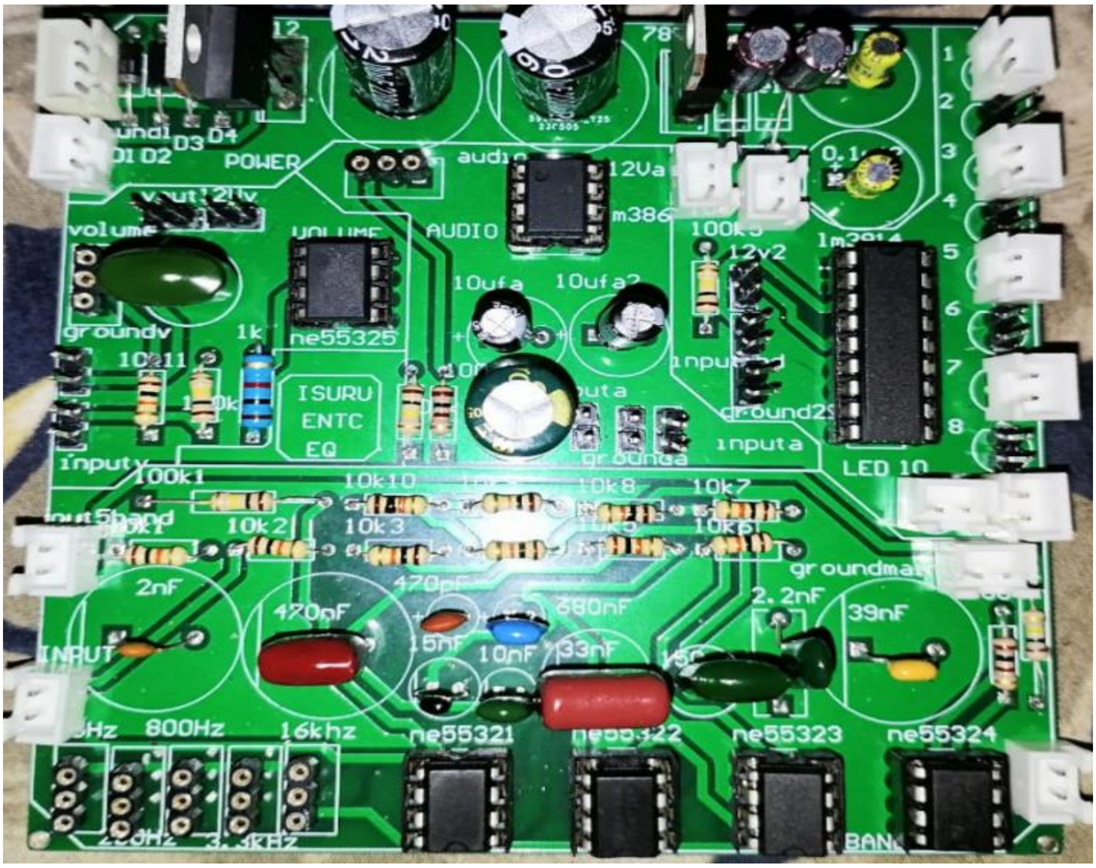


Figure 47: Final PCB

12.2 Appendix B - Enclosure Design

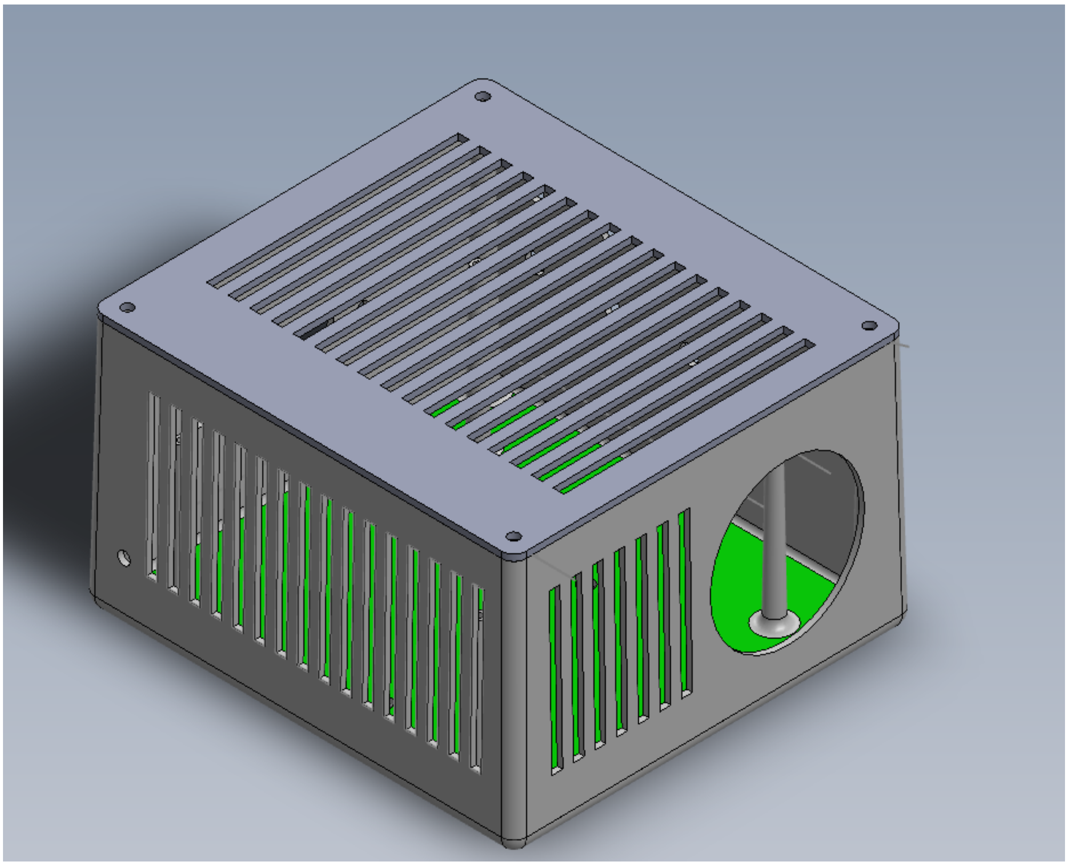


Figure 48.1: Enclosure

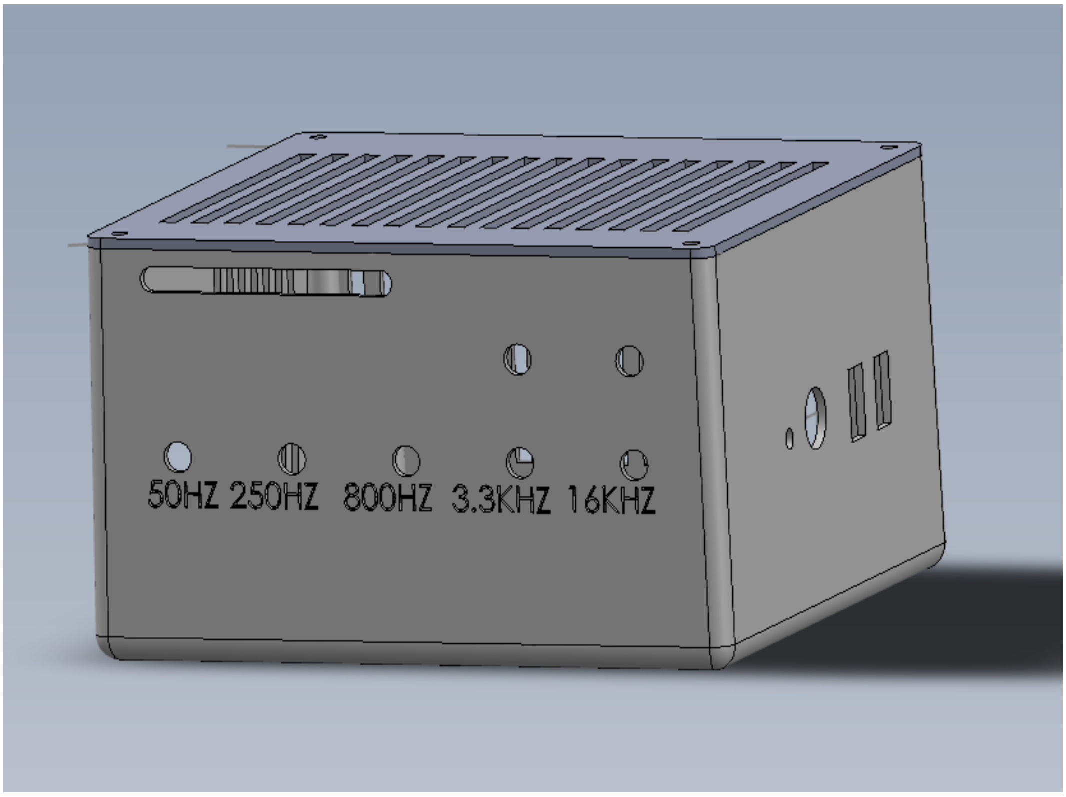


Figure 48.2: Enclosure

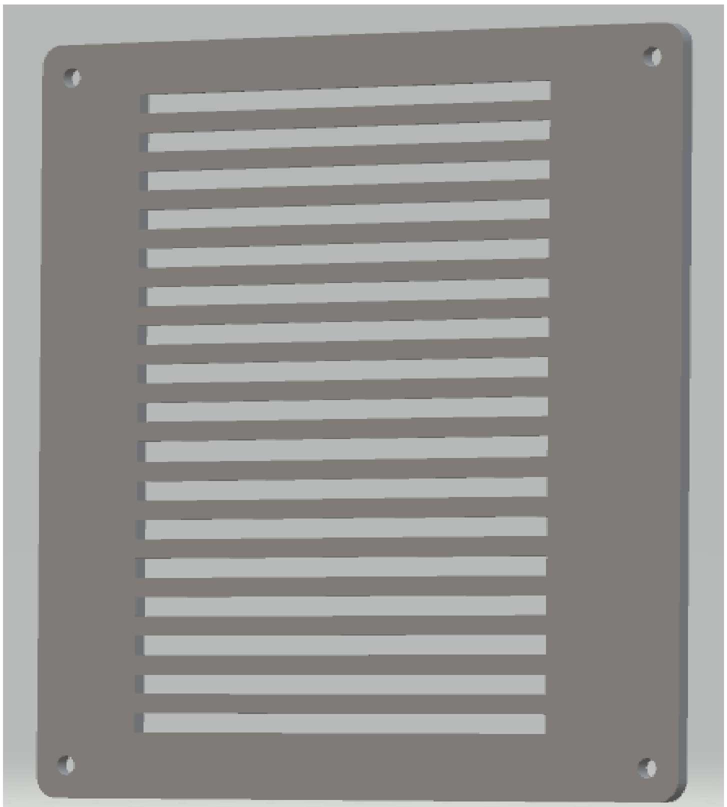


Figure 48.3: Enclosure (Top)

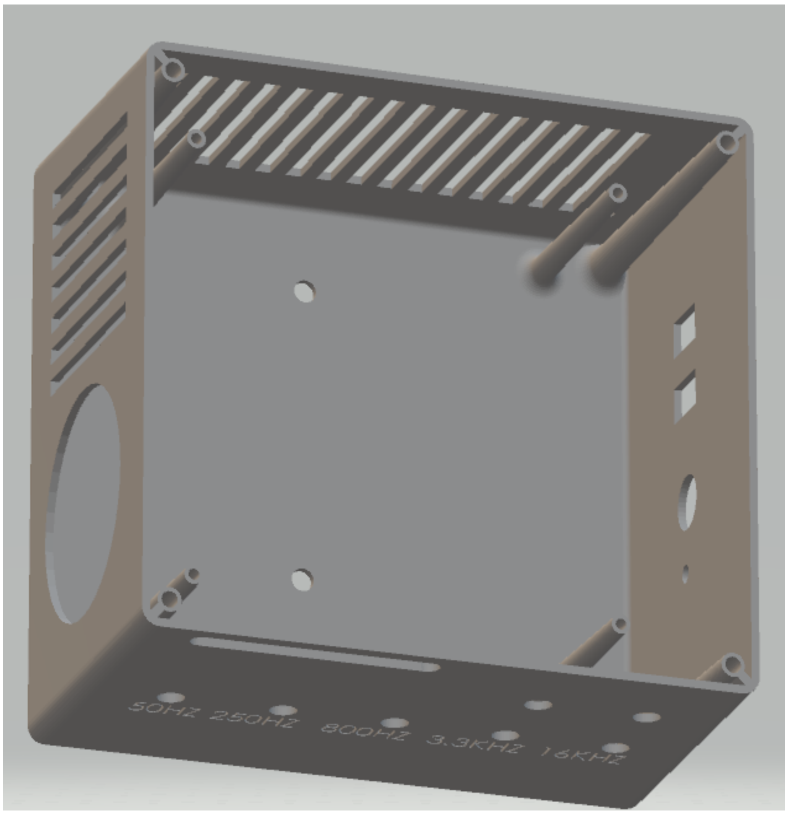


Figure 48.4: Enclosure (Box)

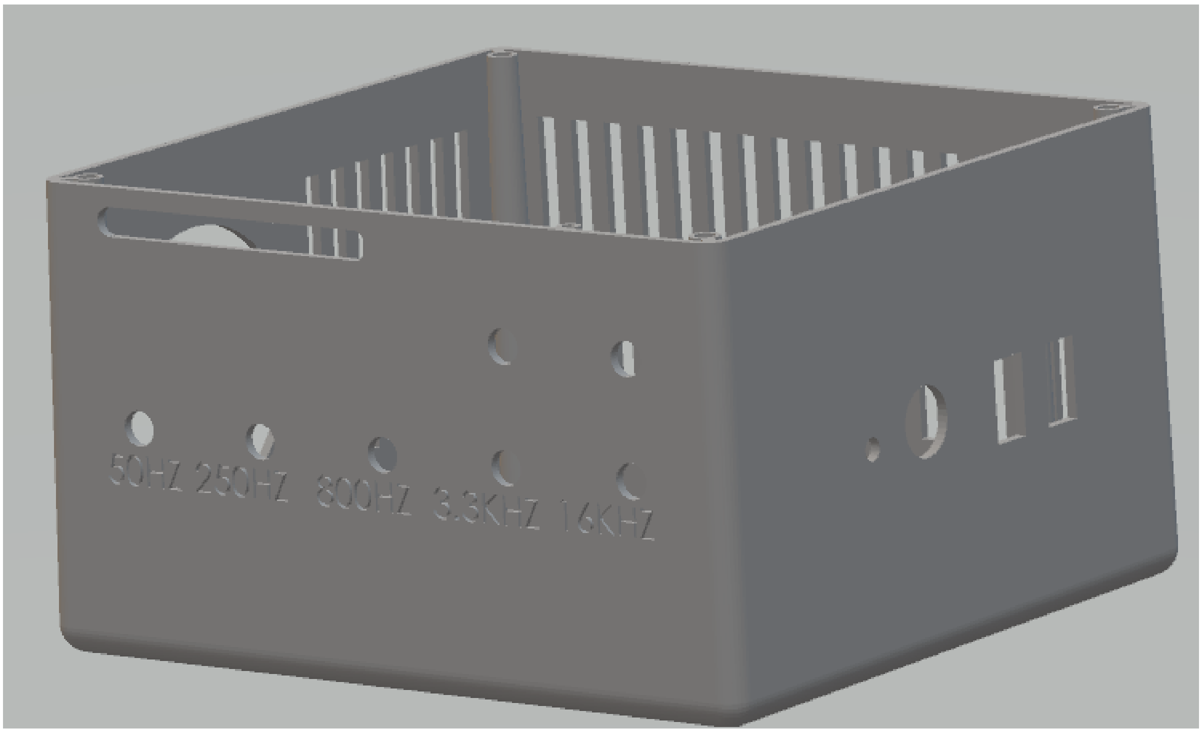


Figure 48.5: Enclosure

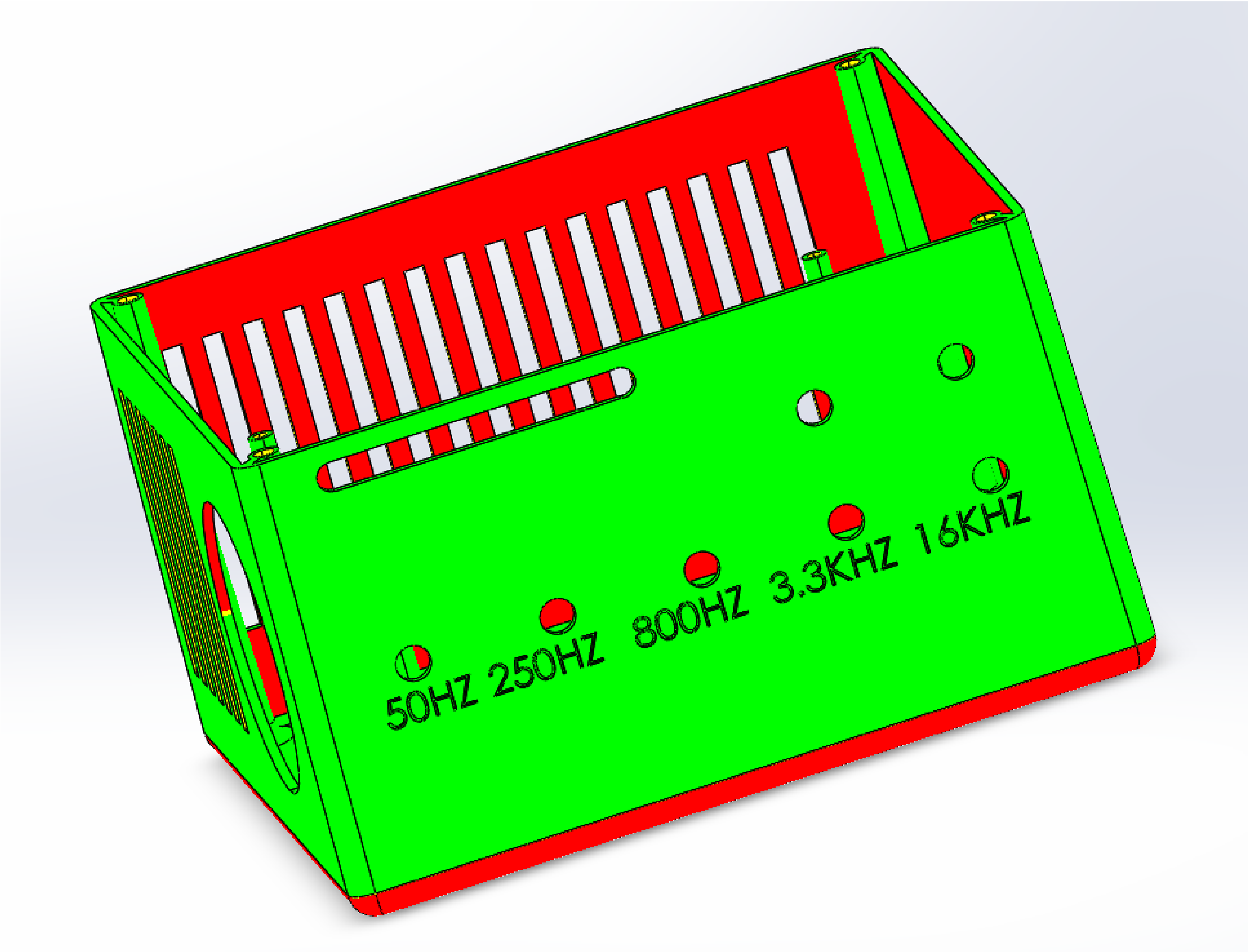


Figure 48.6: Draft analysis -1.00 deg

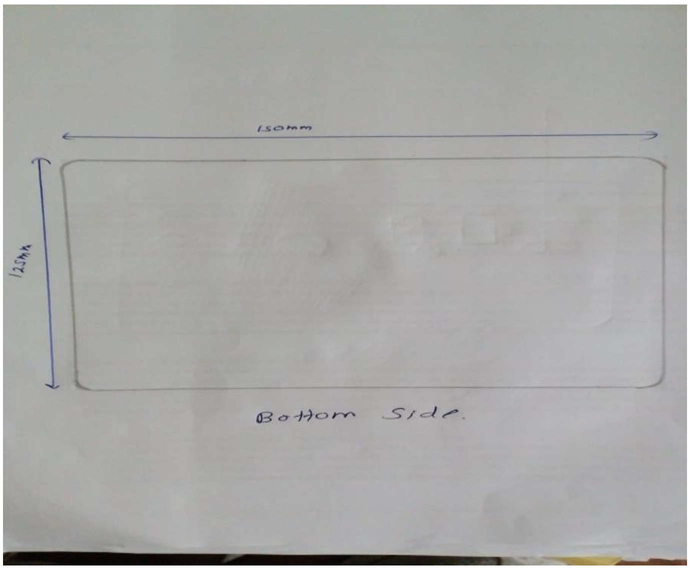


Figure 48.7: Sketch 1

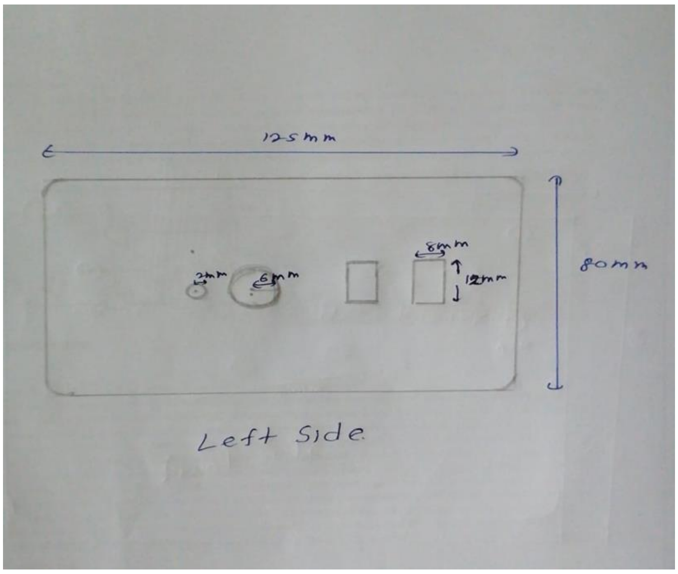


Figure 48.8: Sketch 2

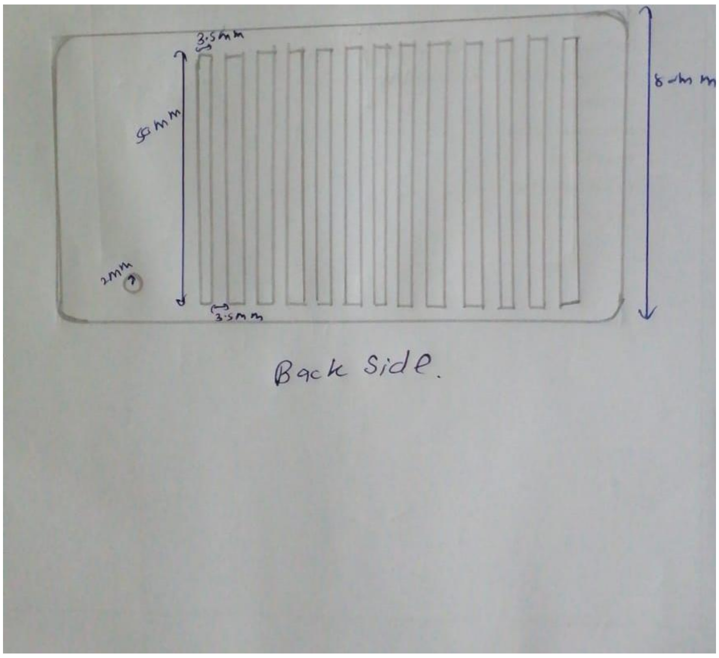


Figure 48.9: Sketch 3

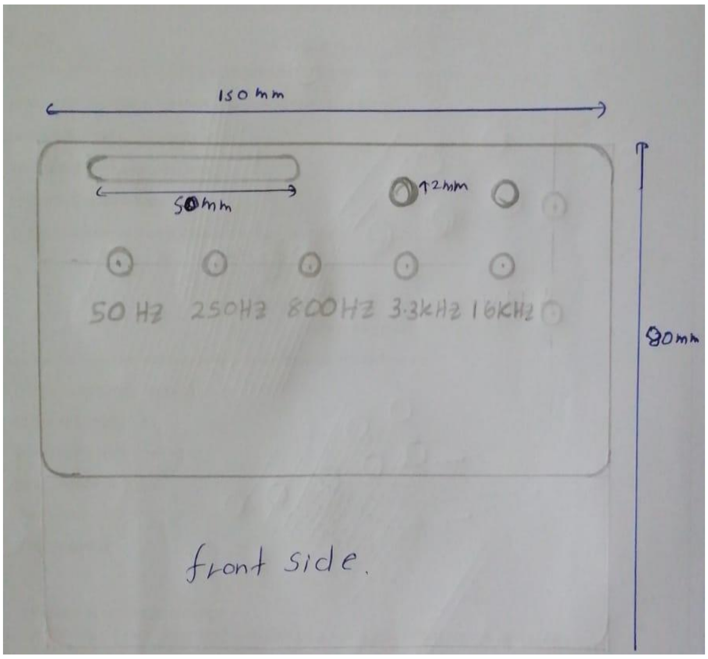


Figure 48.10: Sketch 4

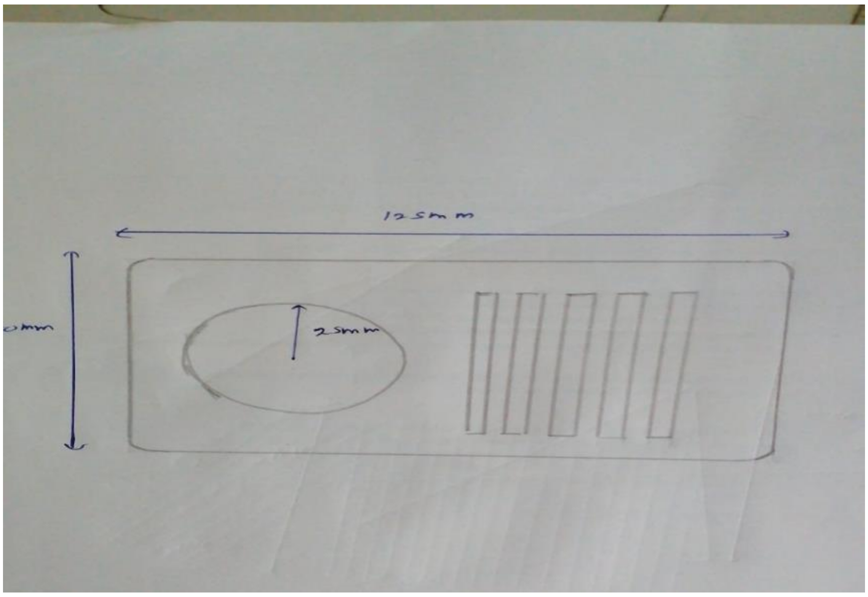


Figure 48.11: Sketch 5

12.3 Appendix C – PCB

12.3.1 PCB schematic

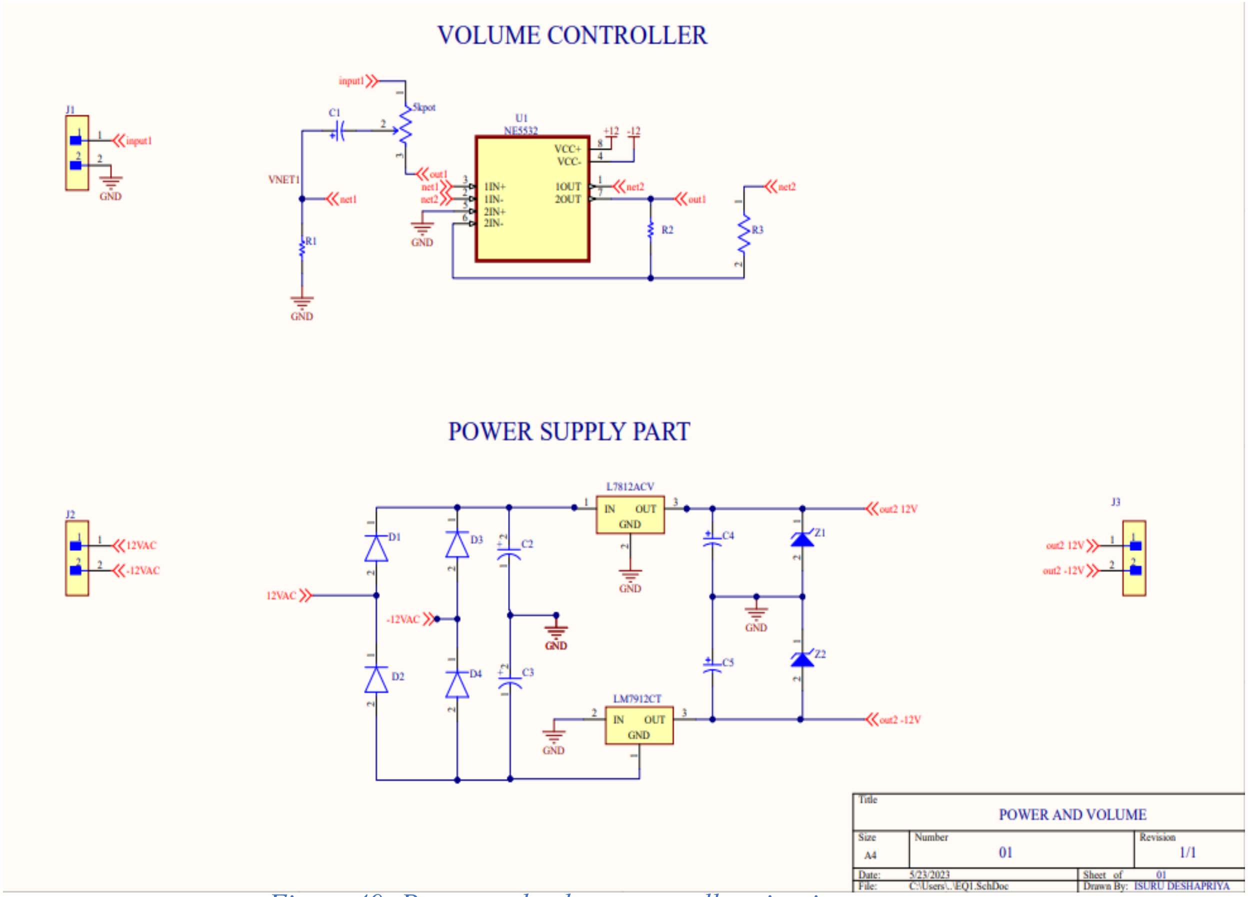


Figure 49: Power and volume controller circuit

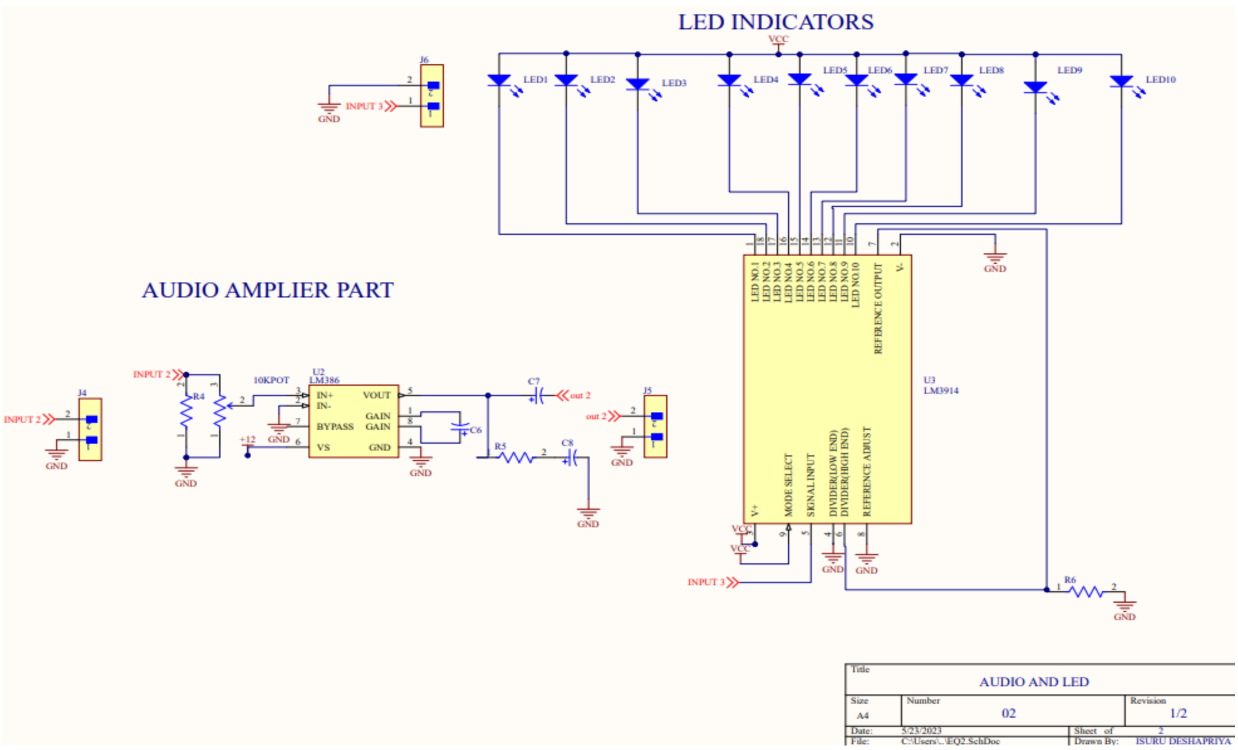


Figure 50: Audio amplifier circuit and LED indicator circuit

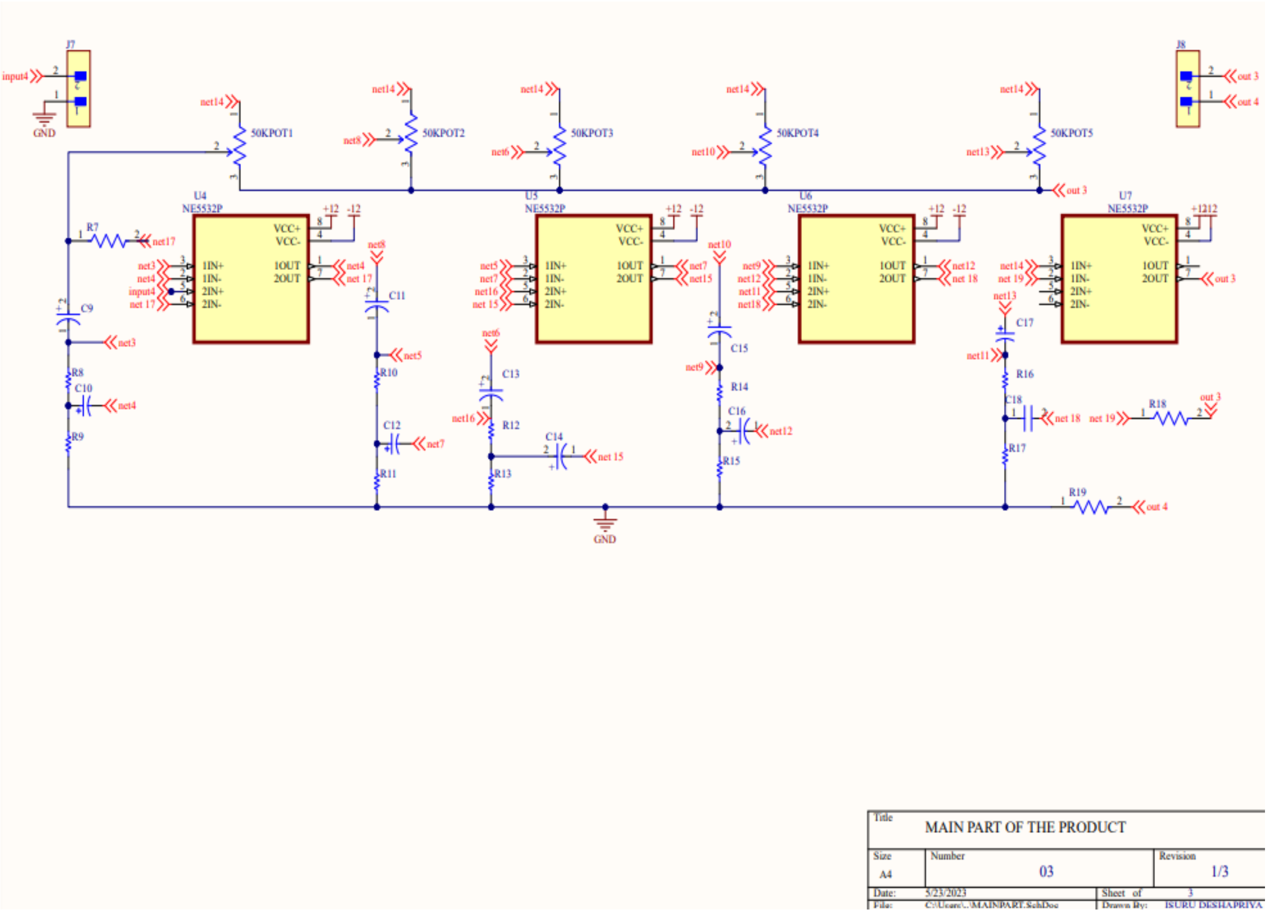


Figure 51: Main circuit

12.3.2 PCB layout

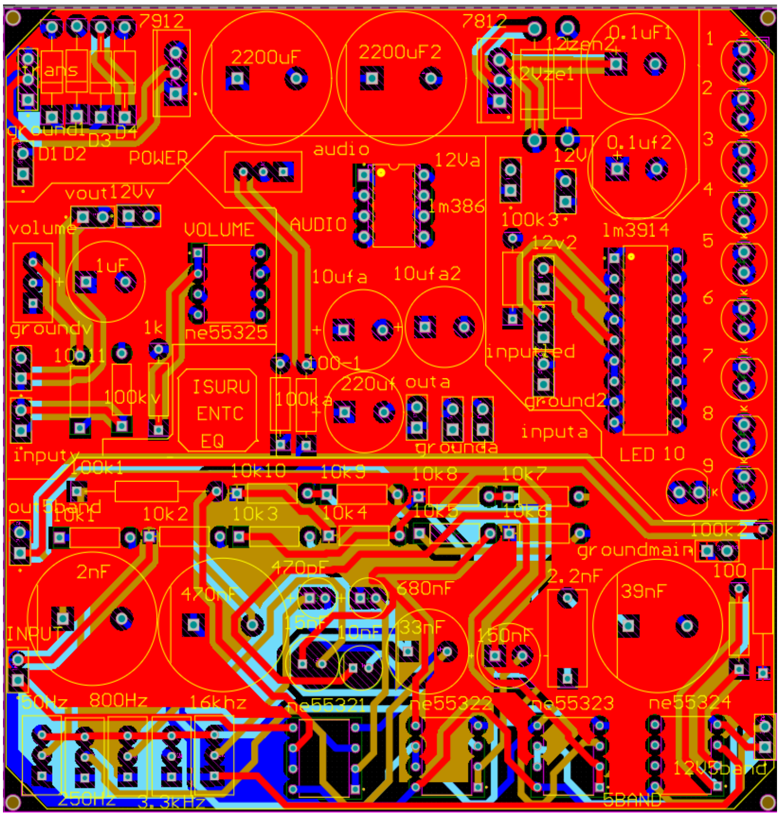


Figure 52.1: PCB layout

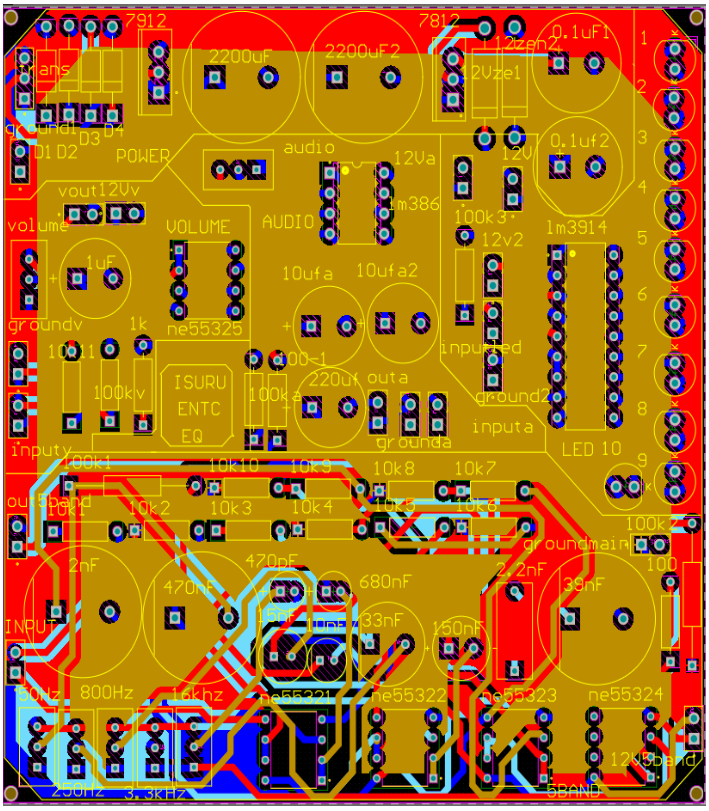


Figure 52.2: PCB layout

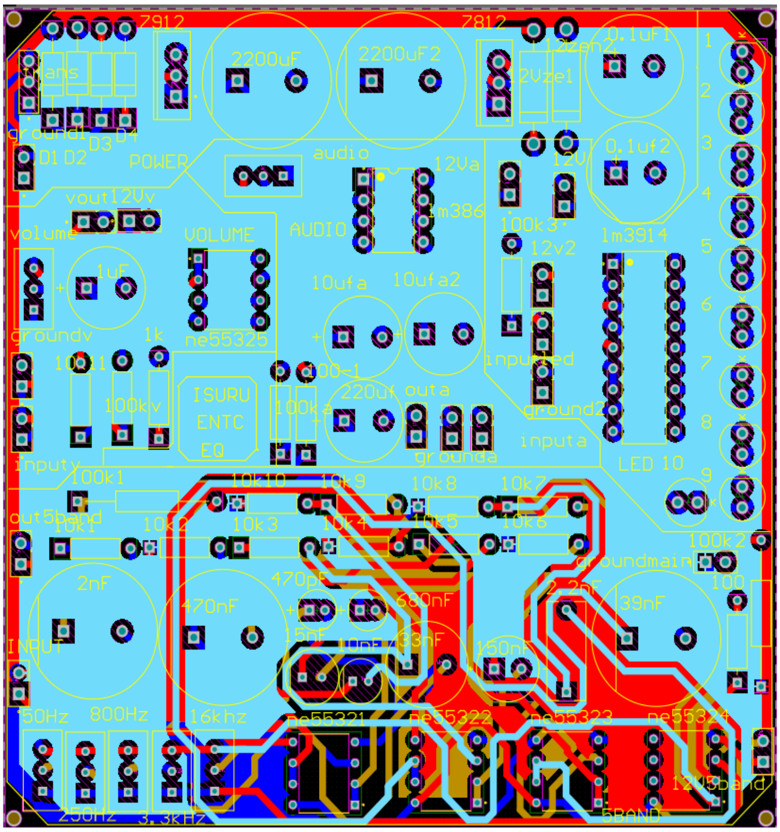


Figure 52.3: PCB layout

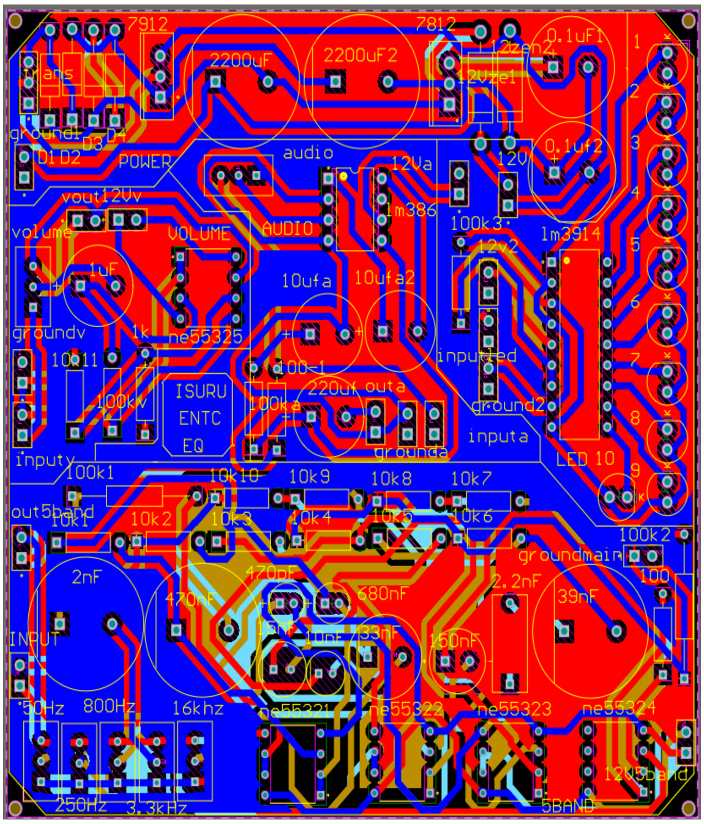


Figure 52.4: PCB layout

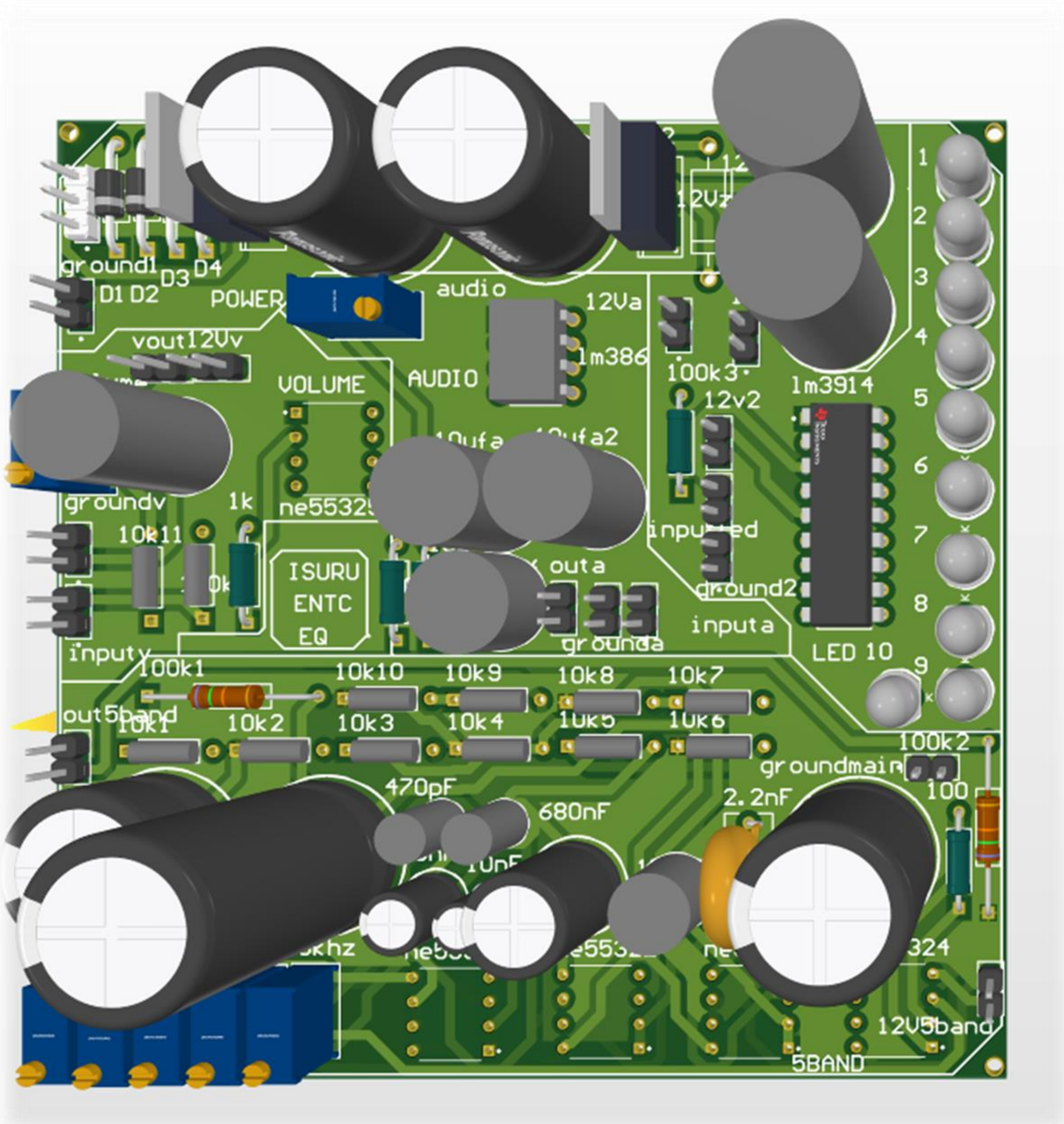


Figure 52.4: PCB 3D view

Gerbers files (Potos)

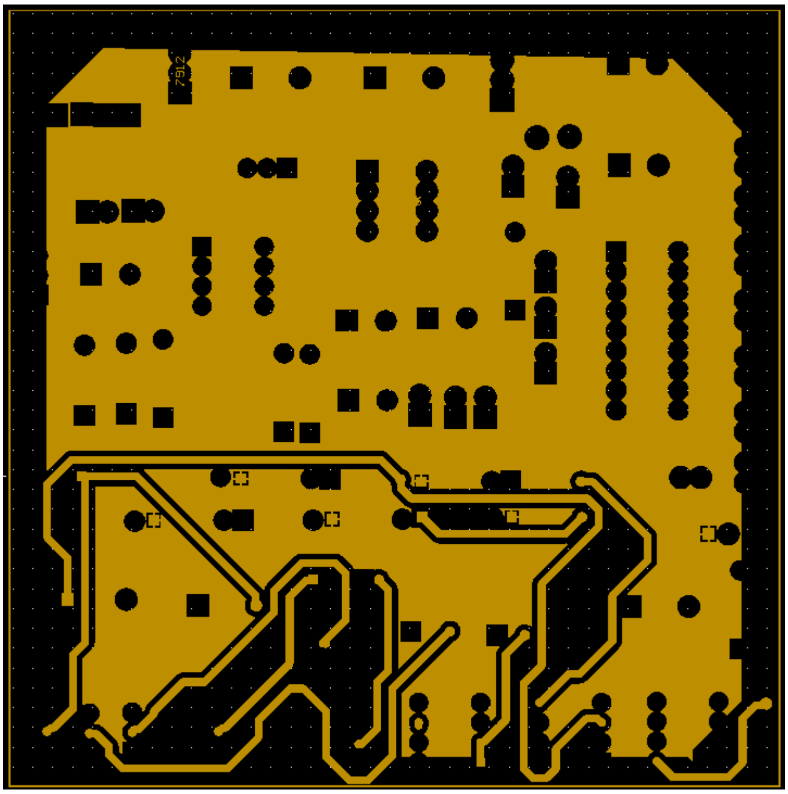


Figure 53.1: Mid layer 1

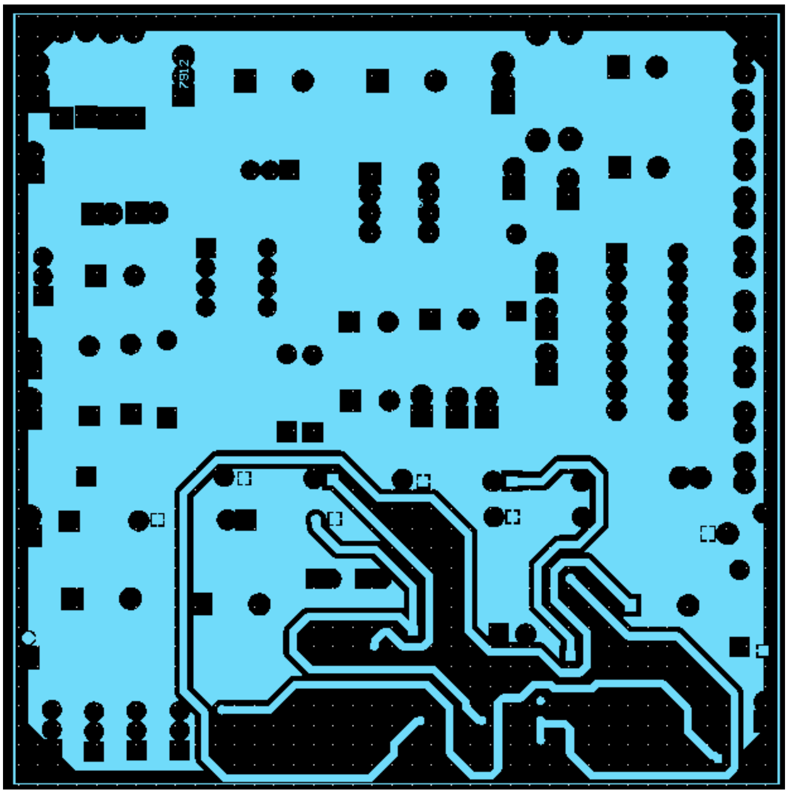


Figure 53.2: Mid layer 2

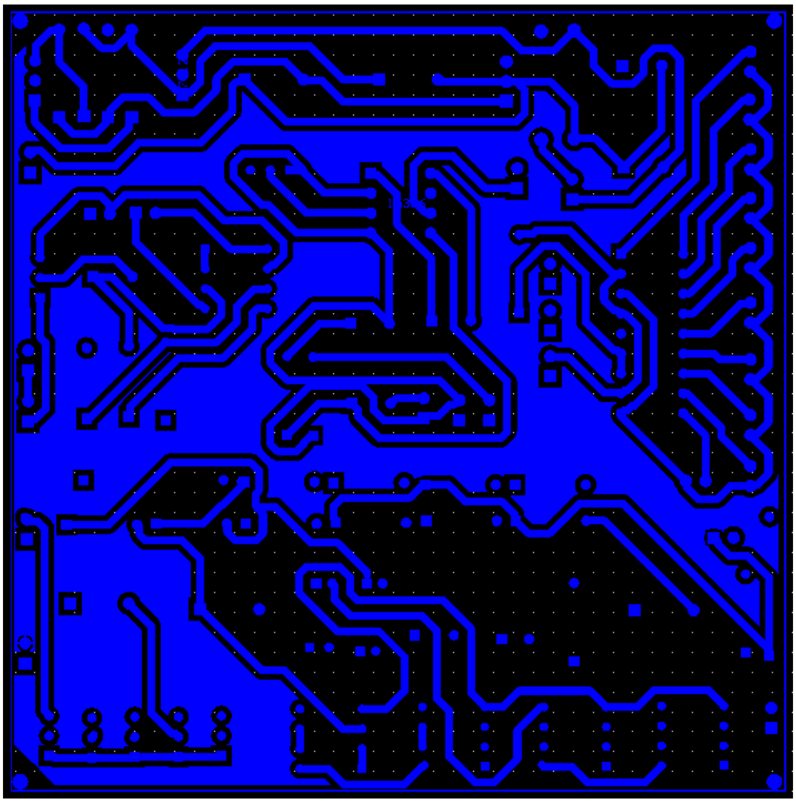


Figure 53.3: Bottom layer

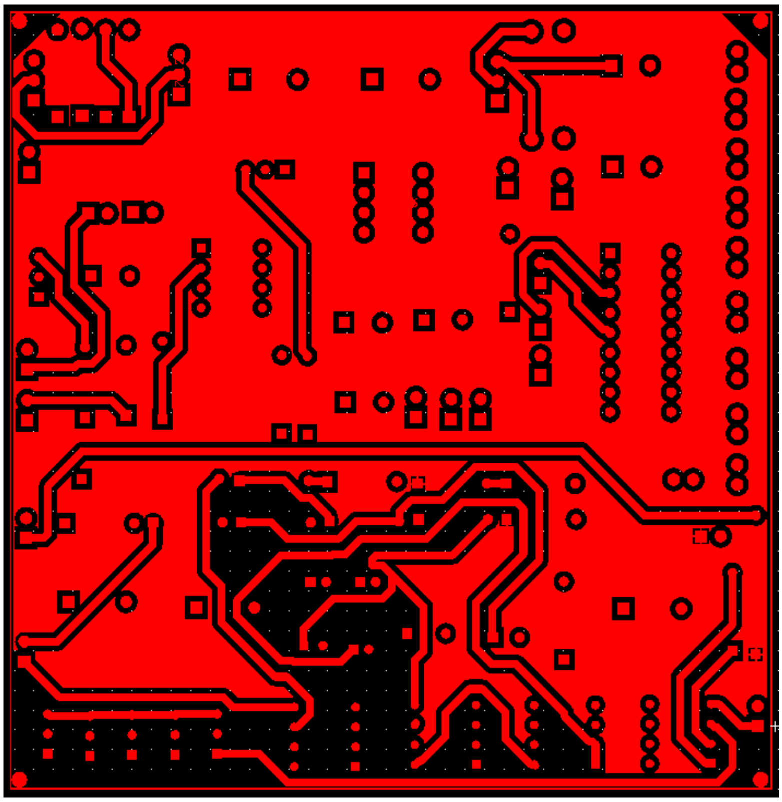


Figure 53.4: Top layer

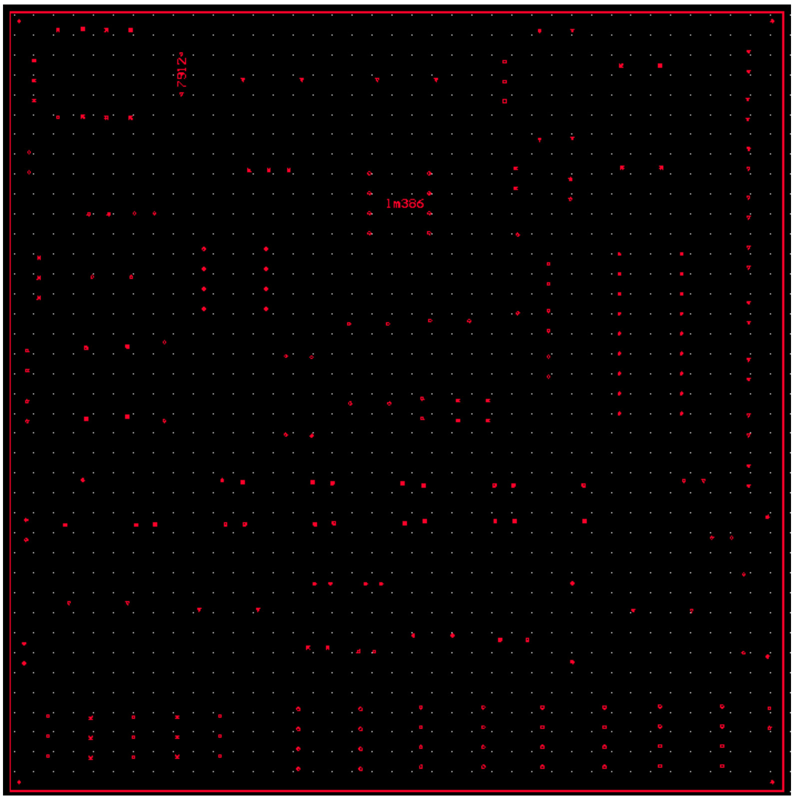


Figure 53.5: Drill file photo

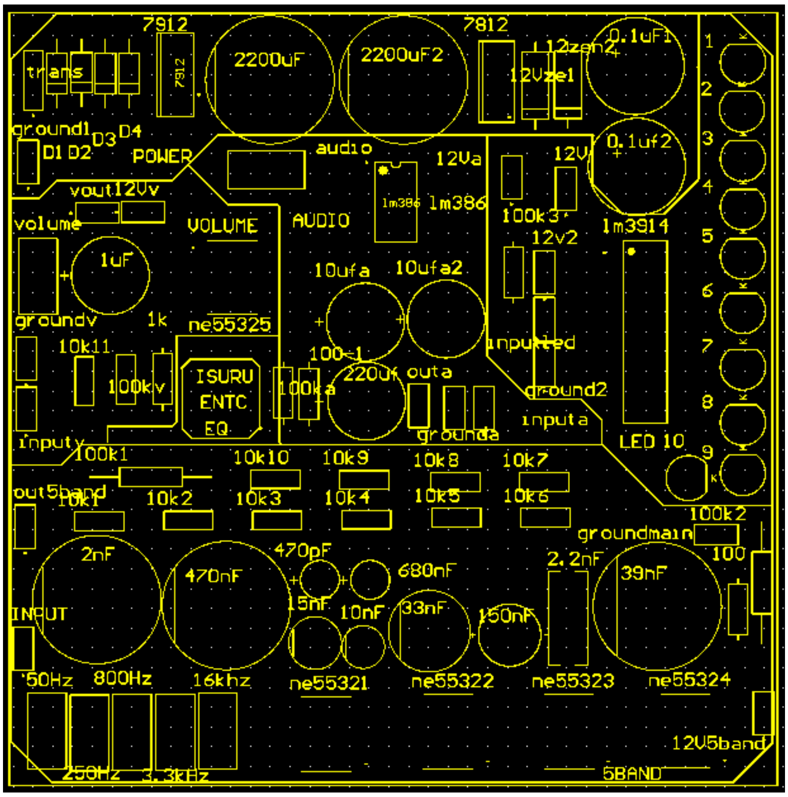


Figure 53.6: Top Overlay layer

13 Bill of materials

Mouser

- NE5532P - https://mou.sr/3oLygUR -7
- LM386N-1/NOPB - https://mou.sr/448TZq3 -1
- L7812CV - https://mou.sr/3nchgXv -1
- L7912CV- https://mou.sr/44onxAj -1
- Multilayer Ceramic Capacitors MLCC - Leaded RAD 50V 0.68uF X7R 10% LS:2.5mm- https://mou.sr/41MtrJG -3
- Multilayer Ceramic Capacitors MLCC - Leaded 200V 0.039uF X7R 10% LS=5.08mm- https://mou.sr/41YYHW5 -2
- Multilayer Ceramic Capacitors MLCC – Leaded-150nF- https://mou.sr/40OFOU2 -1
- Film Capacitors 630VDC 0.033uF 10% LS=10mm AEC-Q200- https://mou.sr/3n7j7No -2

After tax and shipping cost ------Rs.7400.00

Tronic

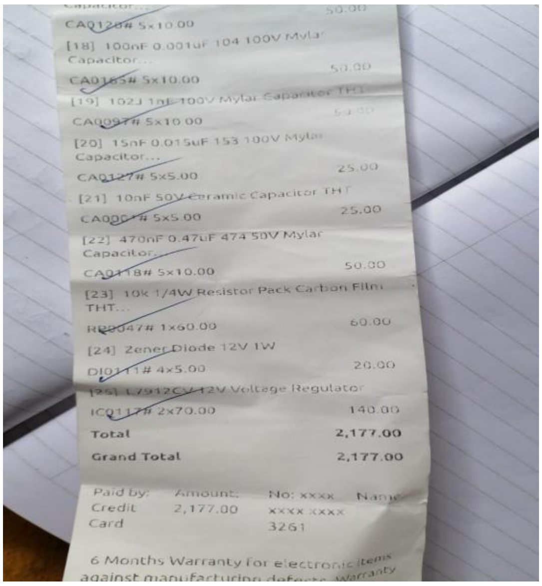

CA0120# 5x10.00 50.00
[18] 100nF 0.001uF 104 100V Mylar Capacitor...
CA0165# 5x10.00 50.00
[19] 102J 1nF 100V Mylar Capacitor THT
CA0097# 5x10.00 50.00
[20] 15nF 0.015uF 153 100V Mylar Capacitor...
CA0127# 5x5.00 25.00
[21] 10nF 50V Ceramic Capacitor THT
CA0067# 5x5.00 25.00
[22] 470nF 0.47uF 474 50V Mylar Capacitor...
CA0118# 5x10.00 50.00
[23] 10k 1/4W Resistor Pack Carbon Film THT...
RP0047# 1x60.00 60.00
[24] Zener Diode 12V 1W
DI0111# 4x5.00 20.00
[25] L7912CV 12V Voltage Regulator
IC0117# 2x70.00 140.00
Total **2,177.00**
Grand Total **2,177.00**
Paid by: Credit Card Amount: 2,177.00 No: xxxx xxxx xxxx 3261 Name
6 Months Warranty for electronic items against manufacturing defects. Warranty

Figure 53: Tronic Bill

COMPONETS	PRICE(Rs)
MOUSER	7400
TRONIC	2177
PCB	6500
ENCLOSER	7350
OTHERS	500
TOTAL	**23927**

Selling Price =Rs.26000

Introduction [3]

Active and Passive Filters [2]

Implementation of audio Equalizer [1]

References

[1] S Cecchi, L Palestini, E Moretti, and F Piazza. A new approach to digital audio equalization. In 2007 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, pages 62–65. IEEE, 2007.

[2] Zhe Chen, Frede Blaabjerg, and John Kim Pedersen. A study of parallel operations of active and passive filters. In 2002 IEEE 33rd Annual IEEE Power Electronics Specialists Conference. Proceedings (Cat. No. 02CH37289), volume 2, pages 1021–1026. ieee, 2002.

[3] JM Vieira. Digital five-band equalizer with linear phase. In Audio Engineering Society Convention 100. Audio Engineering Society, 1996.