University of Moratuwa

Department of Electronics and Telecommunication

EN2160 – Engineering Design Realization

Report

Noise Cancelling Adapter

200356A

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Acknowledgement

This report on Analog Noise Cancelling Adapter project, completed under the electronic part, is being submitted in great pleasure. In order to better grasp this section before learning any theories, we would like to express our profound gratitude to the following people.

My deepest gratitude is conveyed to the head of the department of Electronic and Telecommunication Dr. Ranga Rodrigo and all the senior and junior lecturers who guide us to do such a project. Specially, Dr. Jayathu who gave his views and more ideas in the mid evaluation and helped us in various ways to complete this project.

I would also want to express our gratitude to Prof. J.A.K.S. Jayasinghe for your valuable lectures that helped me accomplish this project in the manner of professional engineers. Analysis, production planning, final product packaging, design strategy, and other topics were all covered in our training. This gave us some insight into how to create the finished product.

Moreover, I convey my gratitude to all my batch mates who helped me immensely by working together and buying components together.

Dulan Lokugeegana,

Electronic and Telecommunication department,

University of Moratuwa,

Sri Lanka.

Abstract

The goal of this project is to buy a product which is readily available in the market and add a new feature which is not existing in that product. I decided to buy a normal headphone and add the new feature noise cancelling to it. The main marketing strategy is the cost saving. Normal headphone noise cancelling headphones are so much expensive. The cost of a normal headphone and the noise cancelling adapter is much less than the cost of noise cancelling headphone. In the first hand I thought of having the noise capturing microphones to be inside the adapter but, I found out that it should be near the ear. So, I had to add the mics with cables which should be attached to the headphone. All the calculations, component selection, PCB design and encloser design was done in such a way that the product is marketable.

Chapter 1 – Introduction

This project was targeting a cost reduced noise cancelling adapter which will cancel the ambient noise up to a certain level. Any headphone can be connected to the adapter and the adapter should be connected to the audio port of the device we are using. Then we have to switch on the adapter so that we can hear the music with noise reduced.

Problem identification

Existing noise cancelling headphones in the market are quite expensive. If a person has a normal headphone and he wants a noise cancelling headphone, that person has to buy an separate headphone to it. It is a waste of money. Considering all these things, it was decided to design a noise cancelling adapter to convert a normal headphone to a noise cancelling headphone. Since this is only an adapter it will be able to make this at lower cost.

Project objectives

Making a noise cancelling adapter at a lower cost. Moreover, there are other factors that should be consider like weight, size, shape, etc.… Most of the market available adapters are only able to be connected to laptops. Therefore, the product objectives are making a noise cancelling adapter which can be connected to any device, and it should be made at a lower cost with reduced size.

Project

The main concept used is capture the noise signal invert it and sum it with the music. Initially noise capturing mics was kept inside the adapter. Then a single mic can capture the noise. Music for the left and the right ears are separately inverted using unity gain inverting amplifier. Next music is added to noise by using a summing amplifier. Finally output the noiseless music for a 3.5mm jack.

First problem occurred is noise capturing. To capture the noise heard to ears the mic should be kept near the ear not in the adapter. Therefore, device needed 2 separate mics to capture the noise and they should be extending outwards. Two separate enclosers were made to insert mic modules which are needed to be connected to the headphone. Both mics are connected from two separate wires.

The second problem is power. Power to make the adapter working cannot be taking from a USB port as this should support any device (which might not have USB port). Therefore, separate replaceable 9V battry was used. Using buck convertor 9V is divided for +4.5V and -4.5V to power up the op amps which is used for amplifiers.

Since electrical signals are travelling at speed of light and sound is much slower comparatively. There should be a delay for negative noise before adding with the music. Therefore, an All Pass Filter is used to compensate it.

Delay calculation

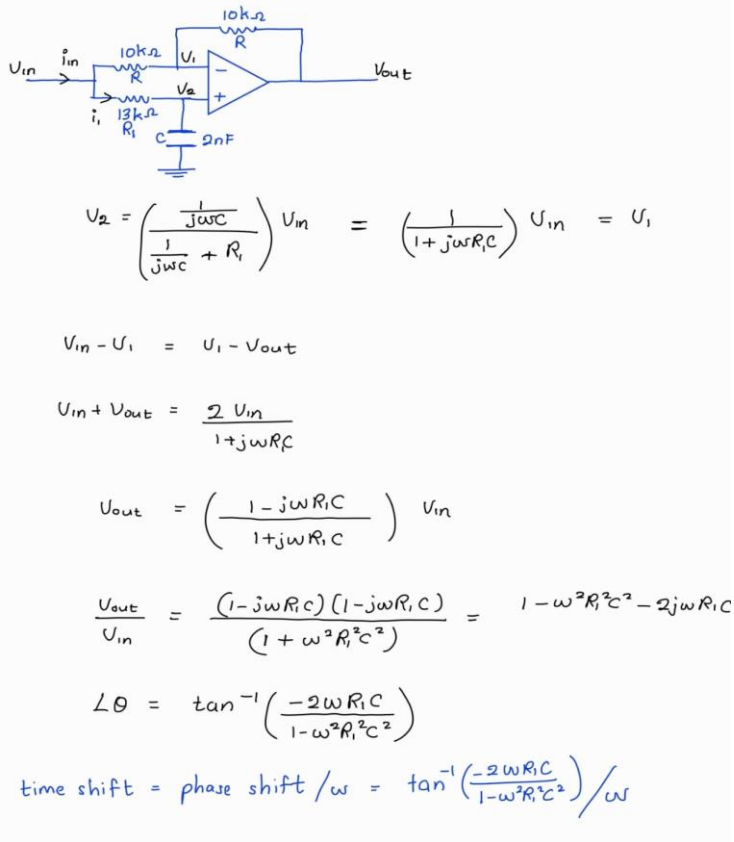

Figure 1 delay calculation

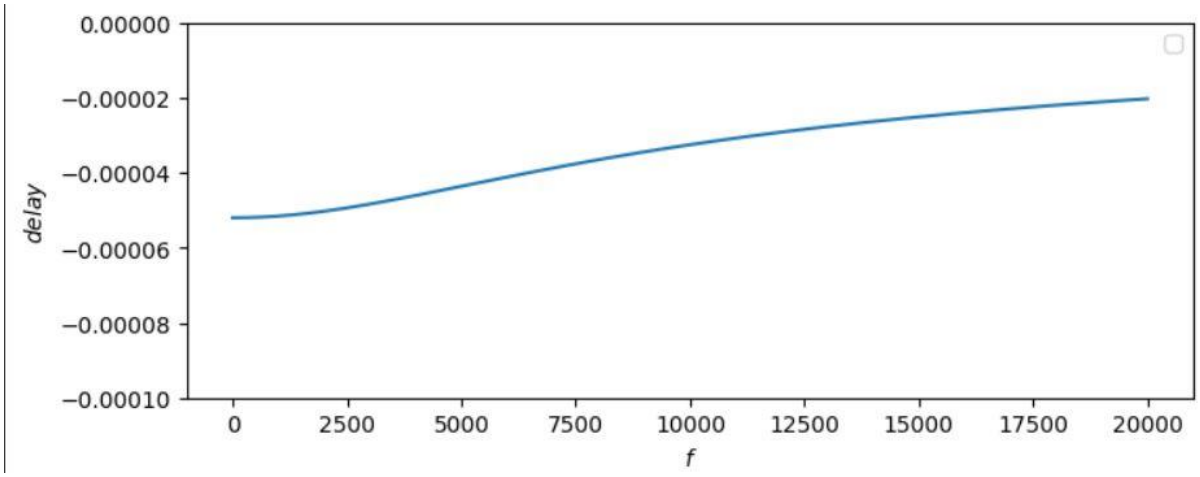

Figure 2 delay curve

Negative phase shift indicates movement to the right.

The mic is kept at about 1.4cm away from the ear.

$330\,ms^{-1}$

$1.4cm$

$time = \frac{1.4 \times 10^{-2}}{330} = 0.000042$

Figure 3 distance time delay calculation

Block diagram

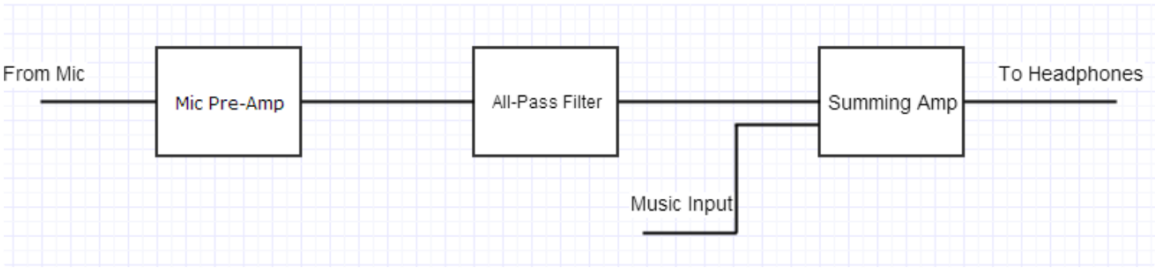

Figure 4 Basic Block Diagram

Basic Circuit Diagram

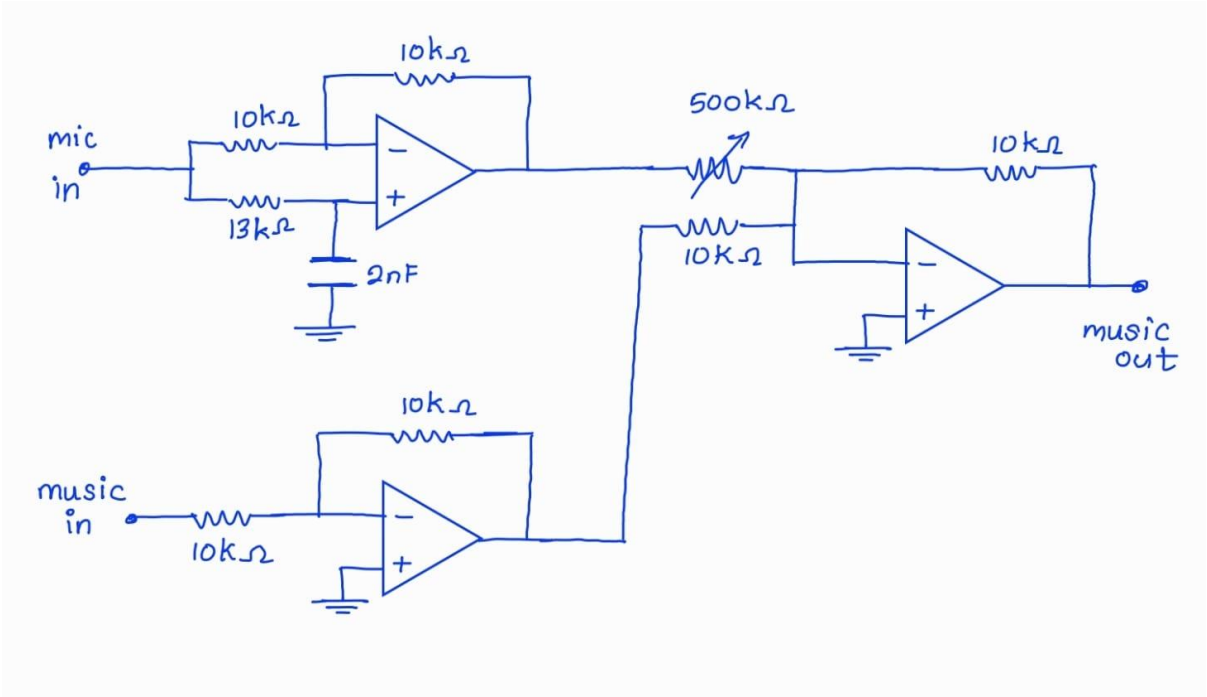

Figure 5 Basic Circuit Diagram

The above circuit modified and review from [1]

Simulation Results

Circuit

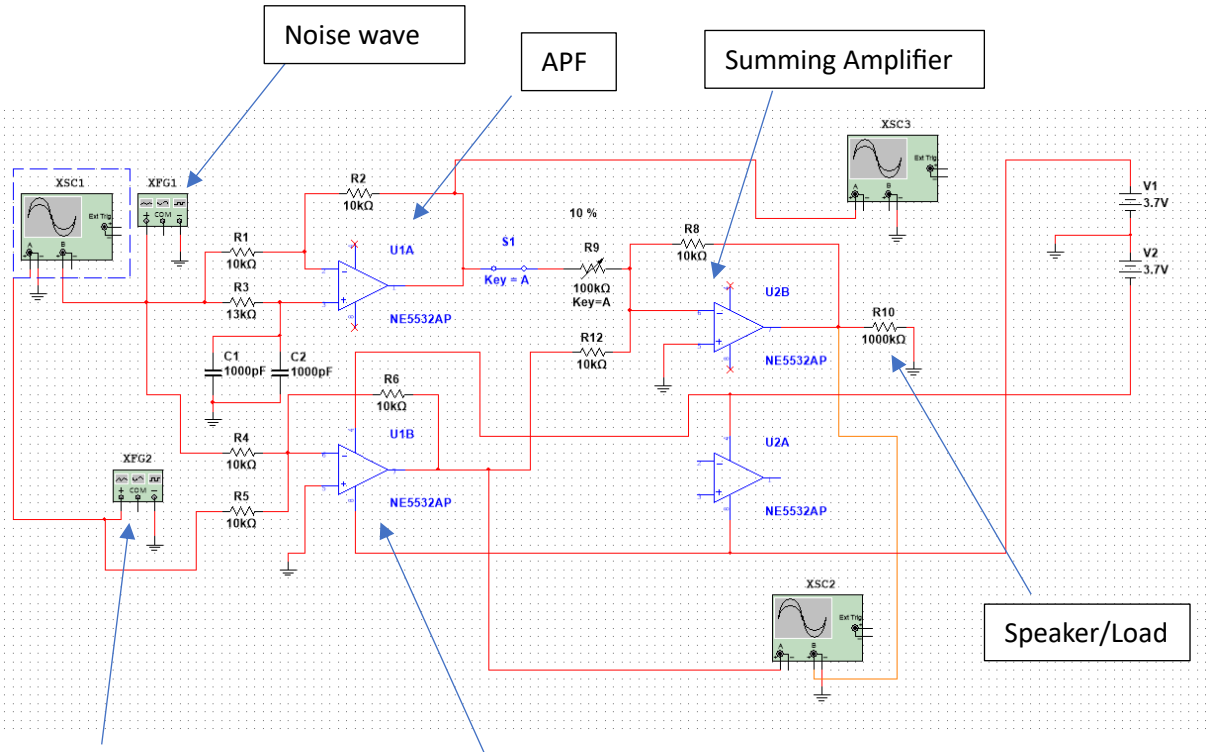

Figure 6 simulation circuit

Music input

Summing amplifier to capture the music + noise signal

For simulation purpose music is represented using a 1V peak voltage 10Hz Sine wave.

Noise is represented using a 300mV peak voltage 50Hz Sine wave.

Additional Summing amplifier is used to see the noise + music to be compared.

Then noise is captured and reduced to form the clear music which are shown by pictures in the next page.

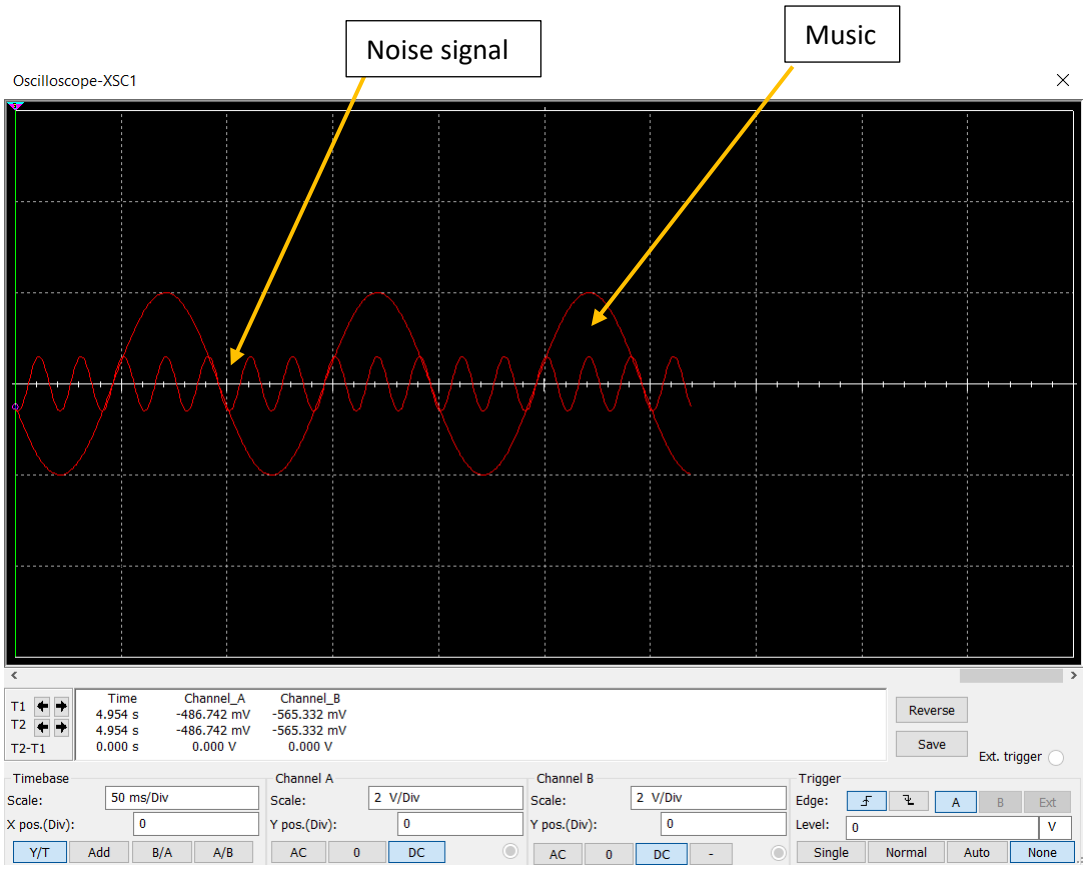

Figure 7 simulation result 1

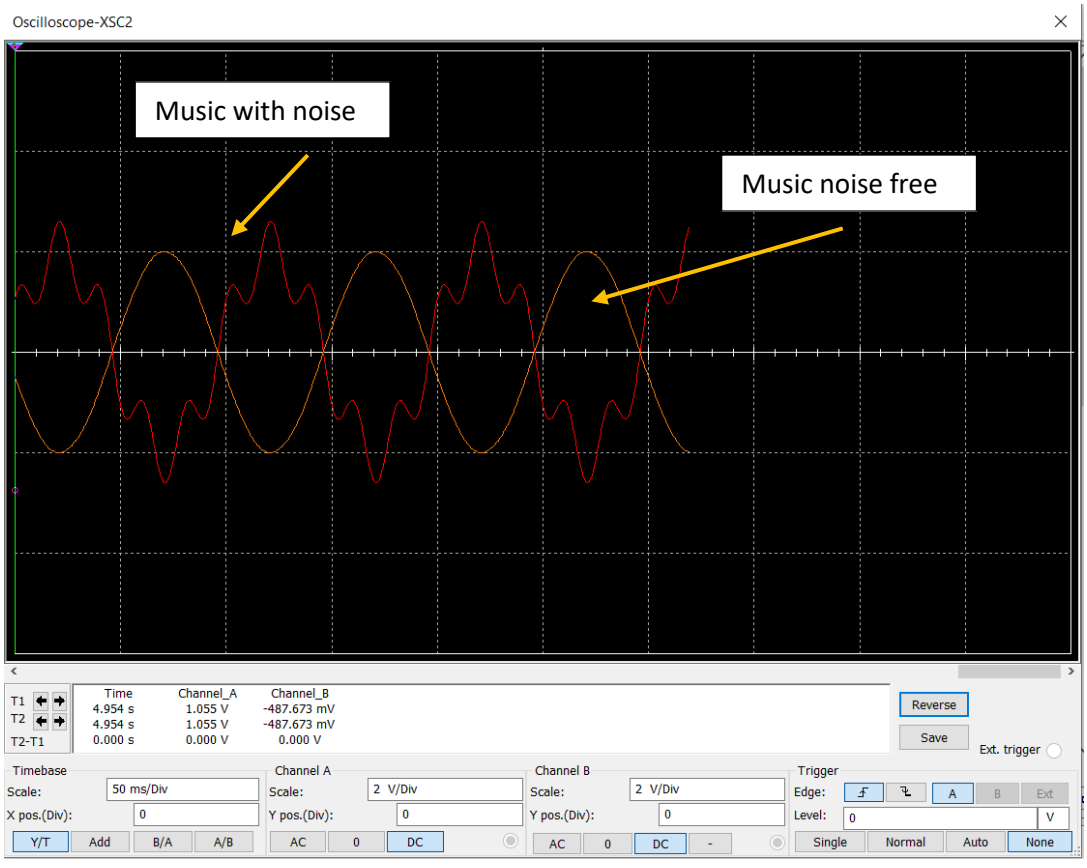

Figure 8 simulation result 2

Chapter 2 – conceptual report

Conceptual design was done with the group members to get more ideas and their opinion on designing the product.

Sketches Drawn by Group Members

Sketch 1
Drawn by Amarasinghe Y.E - 200029B

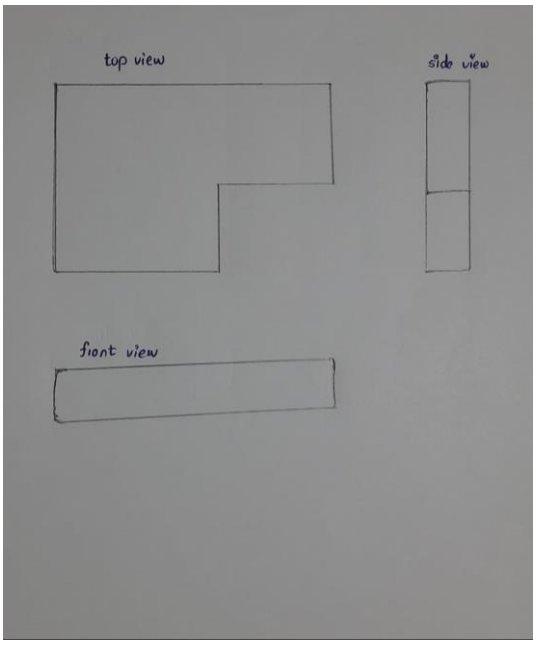

Figure 10 sketch 1

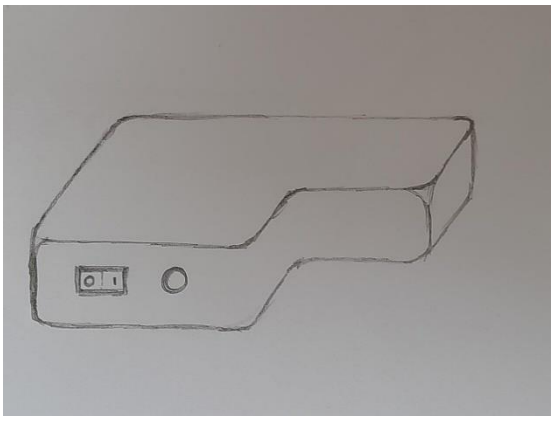

Figure 9 3D view 1

Sketch 2

Drawn by Vishagar A - 200686J

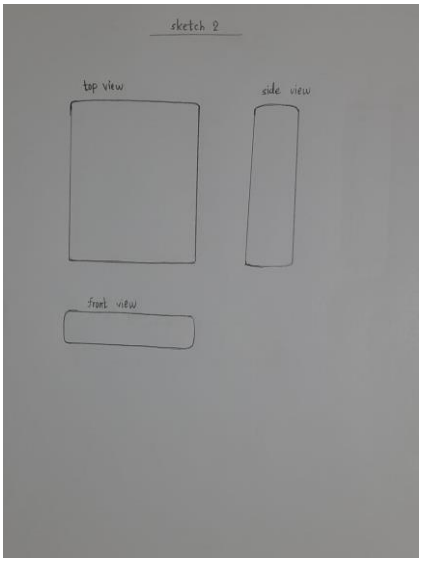

Figure 11 sketch 2

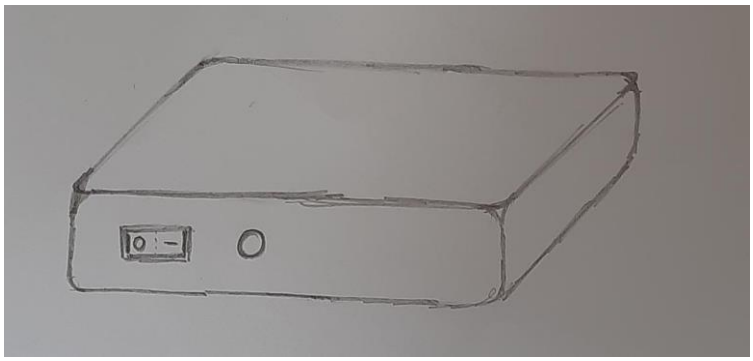

Figure 12 3D view 2

Sketch 3

Drawn by Liyanage P.H.S. – 200352H

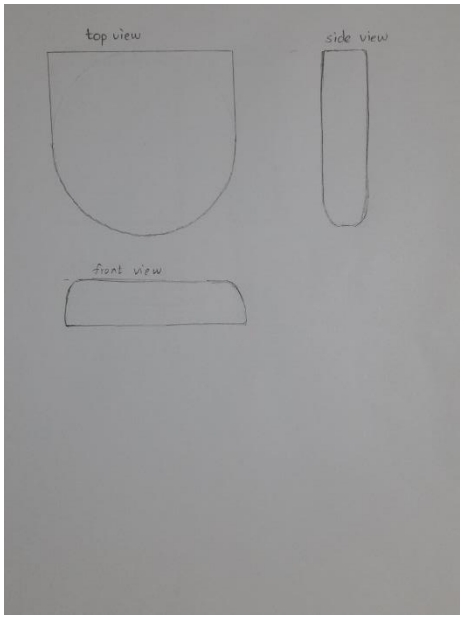

Figure 13 sketch 3

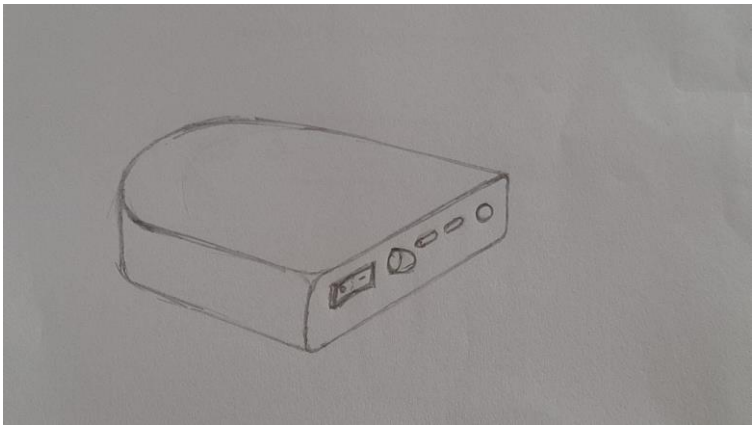

Figure 14 3D view 3

Summary of user feedback

1. The product is highly effective for users.
2. It should be little more affordable.
3. Minimum size.
4. Appearance and shape don't matter much but, it should be smaller as possible.
5. Extra feature Bluetooth.

User Feedback sketches

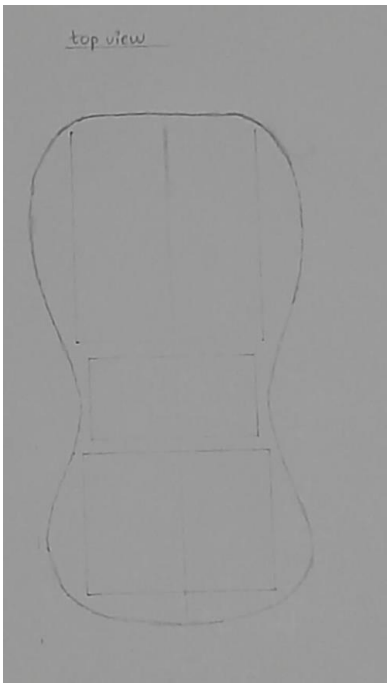

Figure 17 user feedback top view

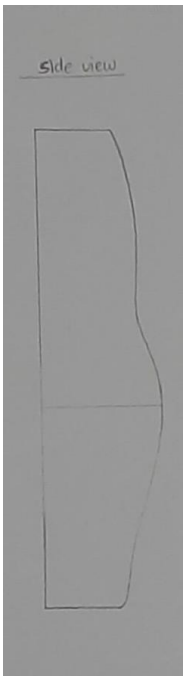

Figure 16 user feedback side view

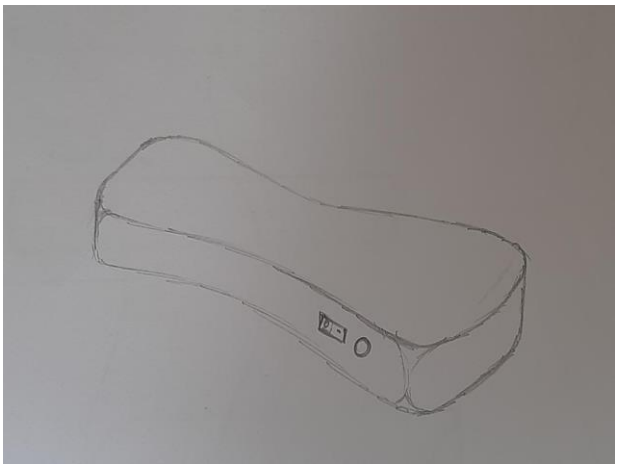

Figure 15 user feedback 3D view

Sketches are drawn such that it will be more easy to use and with an attractive shape.

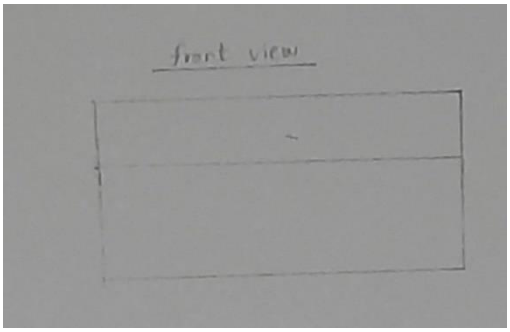

Figure 18 user feedback front view

Evaluation for Sketches

Graded form 1-5, where 5 is the best.

Criteria	Sketch 1	Sketch 2	Sketch 3	User
User Interface	4	4	4	5
Stability	5	5	4	5
Durability	4	5	4	5
Novelty	5	3	5	5
User friendliness	5	5	5	5
Mobility	5	5	4	5
Reliability	3	5	4	4
Cost	3	4	4	4
Maintainance	4	5	3	4
Simplicity	2	5	4	5
Weight	3	4	4	4
Attractiveness	4	2	4	5
Total	47	52	49	56

Block Diagram

Block 1

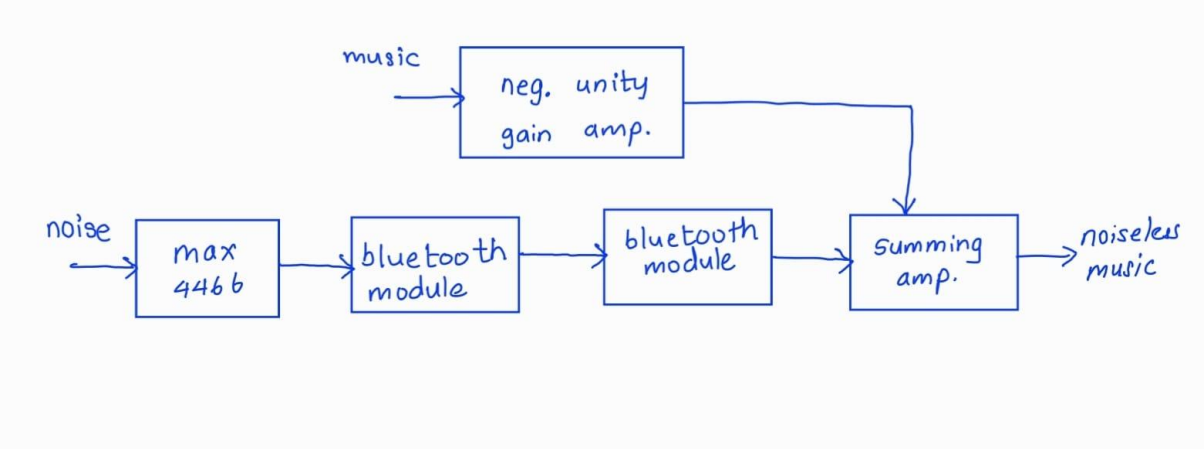

Figure 19 block diagram 1

Block 2

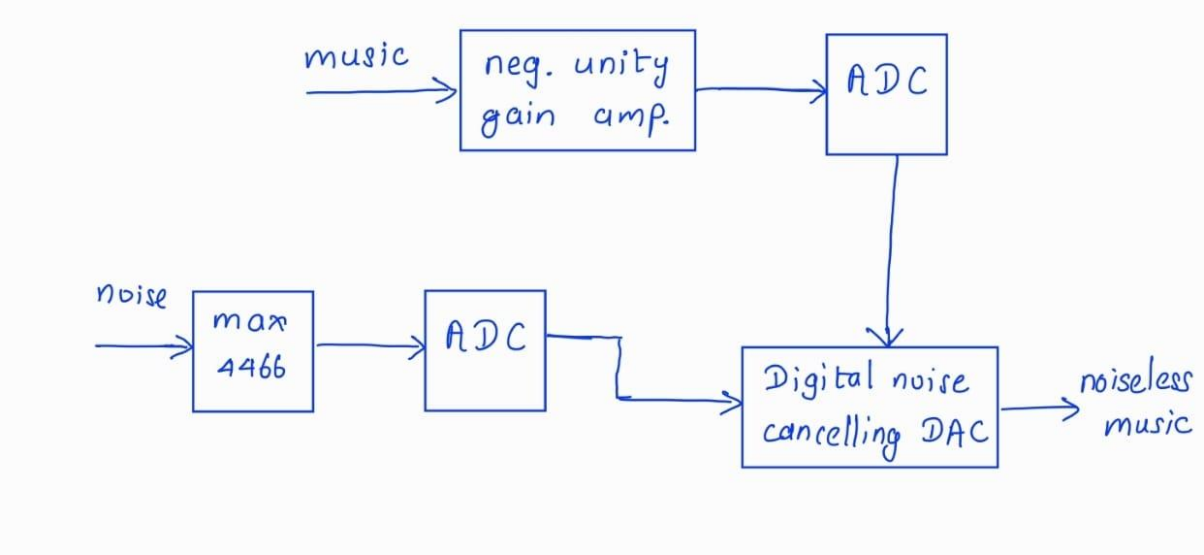

Figure 20 block diagram 2

Block 3

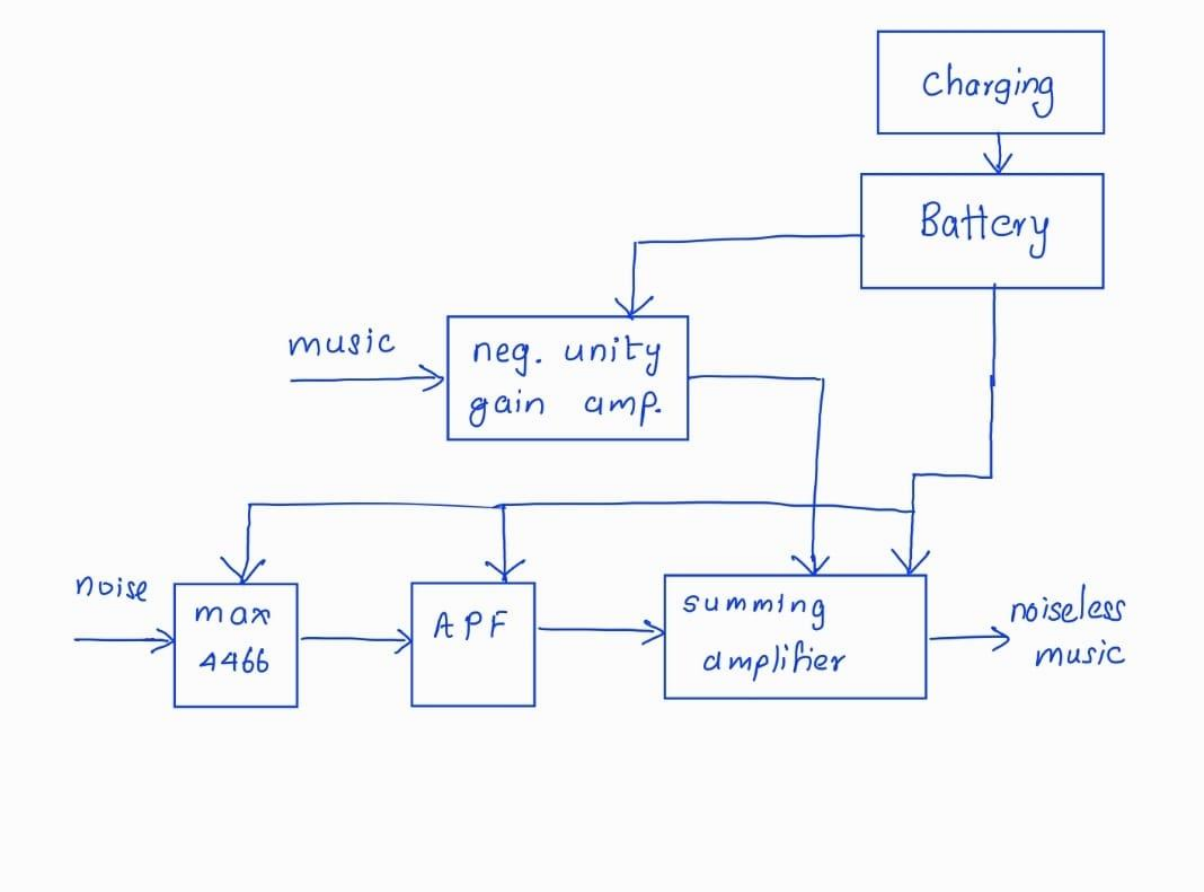

Figure 21 block diagram 3

User Feedback Block Diagram

Block diagram is same as this is the only circuit for analog noise cancelling. Therefore, this is chosen.

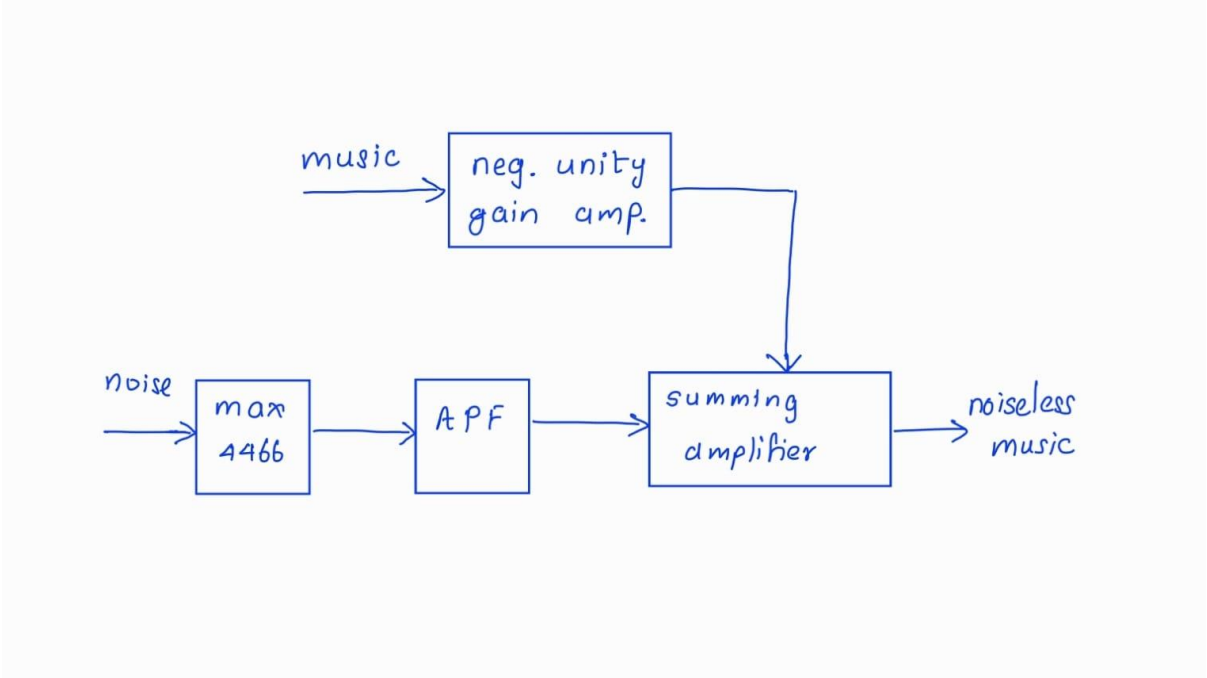

Figure 22 user feedback block diagram

The above block diagram is selected for the Preliminary Design.

Bluetooth addition feature is discarded as this will be an analogue circuit.

Evaluation for block diagram

Graded form 1-5, where 5 is the best

Criteria	User Block Diagram	Block Diagram 1	Block Diagram 2	Block Diagram 3
Simplicity	5	3	3	4
Accuracy	2	4	3	2
User friendly	3	3	3	3
Updatability	4	1	3	4
Troubleshooting	5	2	2	5
Feasibility	5	3	1	5
Durability	5	3	3	5
Total	29	19	18	28

Selected Sketches

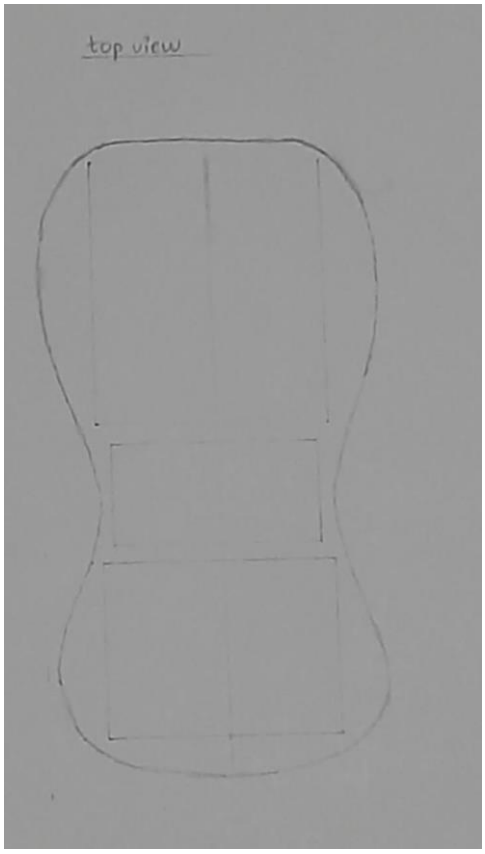

Figure 25 selected sketch top view

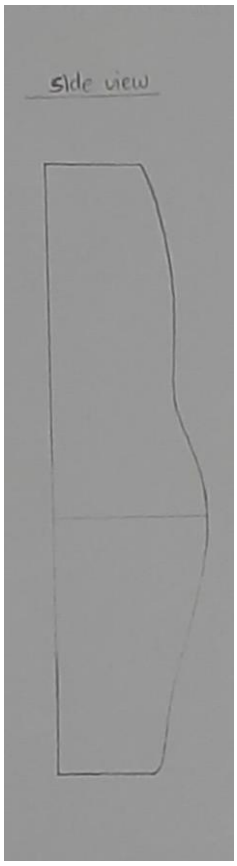

Figure 24 selected sketch side view

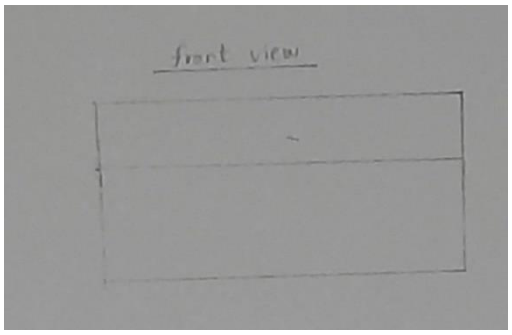

Figure 23 selected sketch front view

Selected Schematic

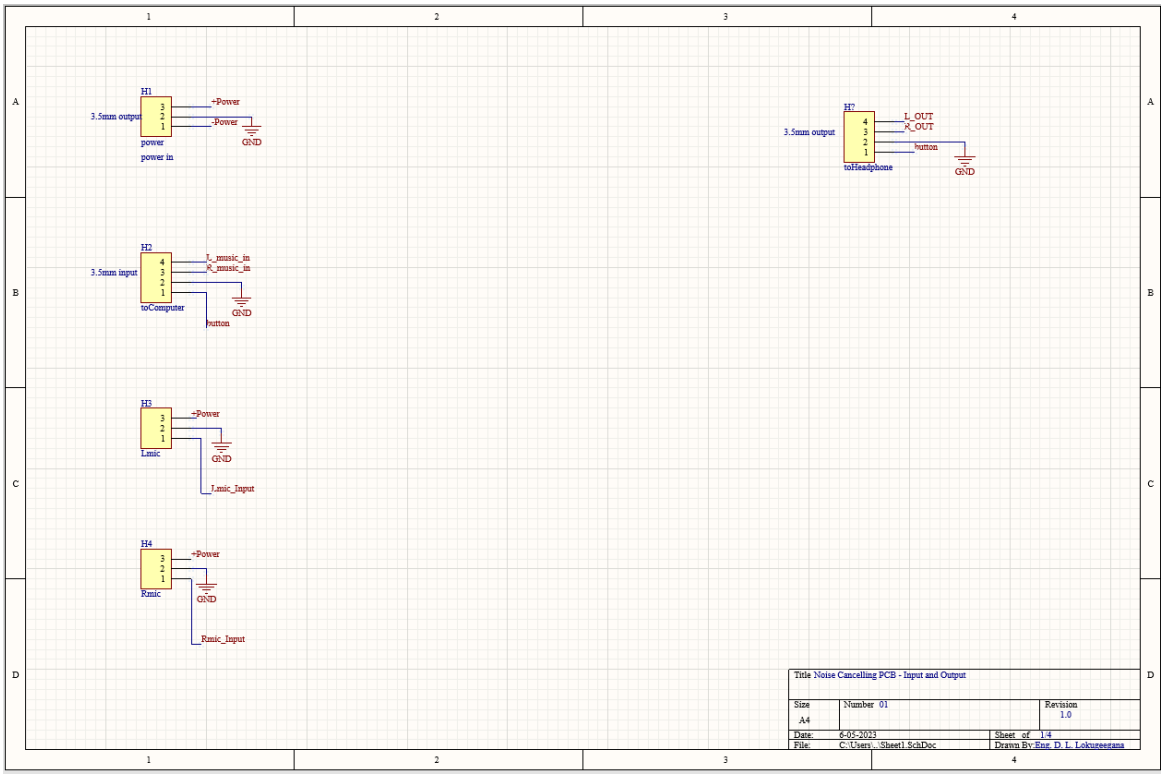

Figure 26 selected schematic sheet 1

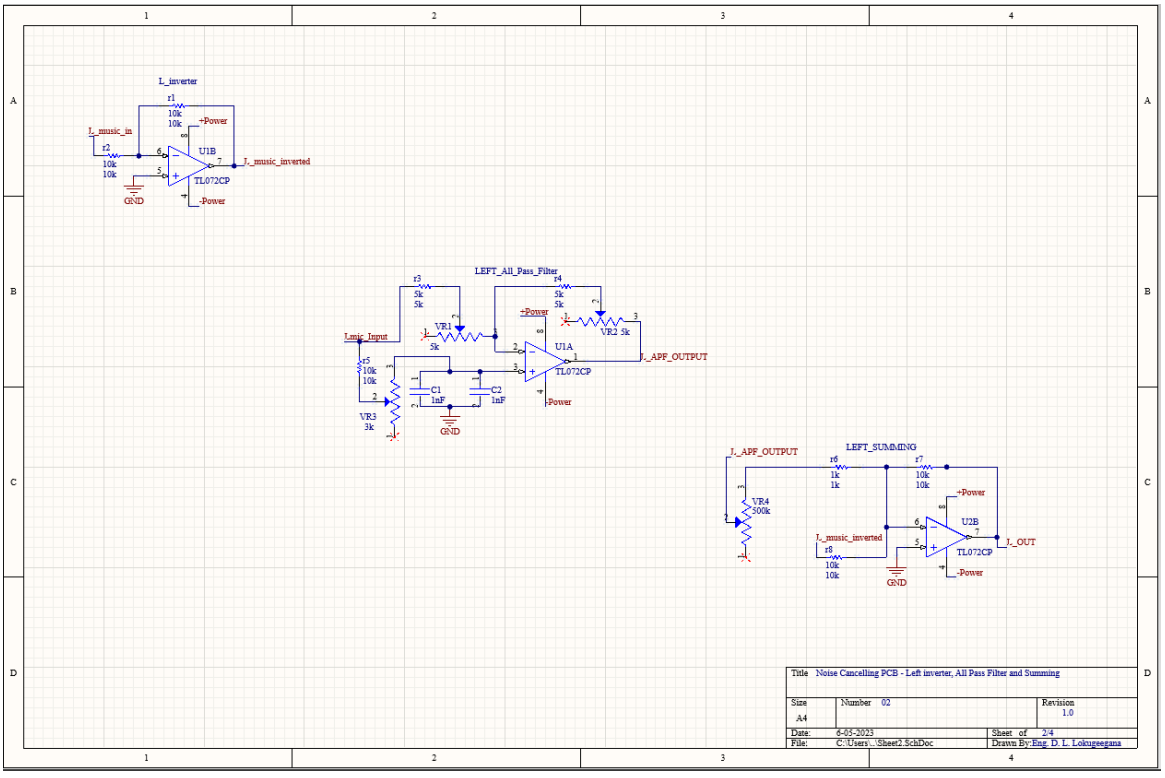

Figure 27 selected schematic sheet 2

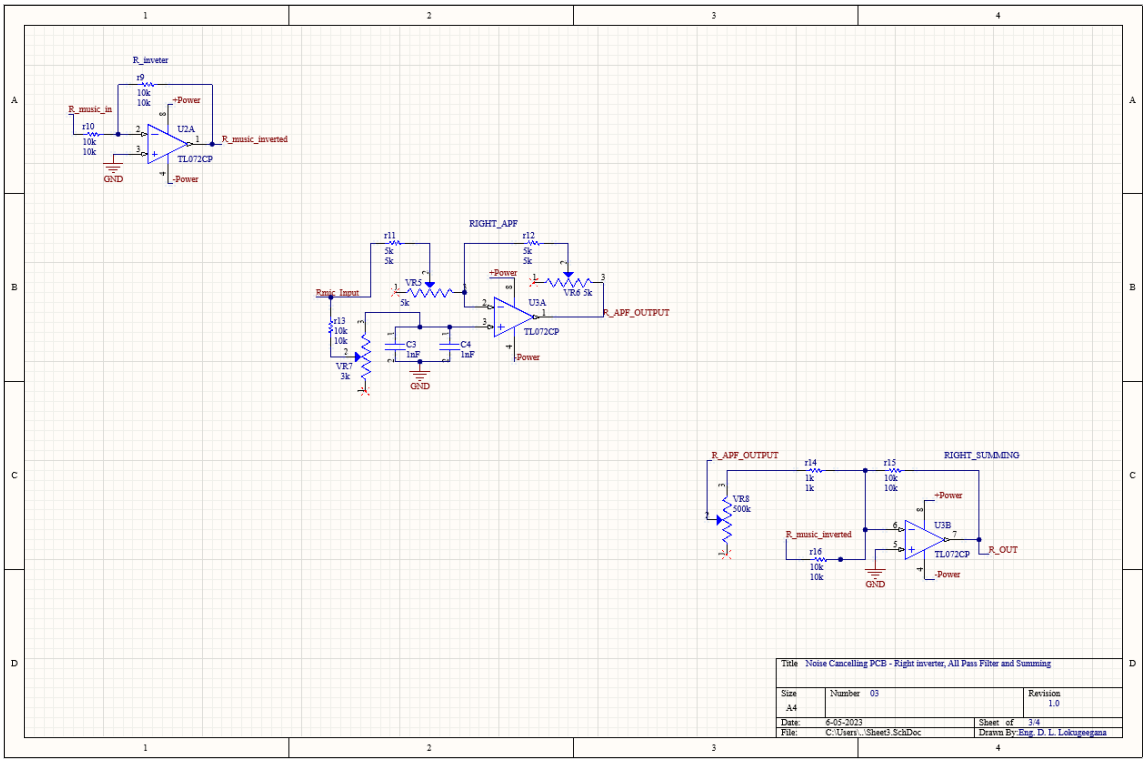

Figure 28 selected schematic sheet 3

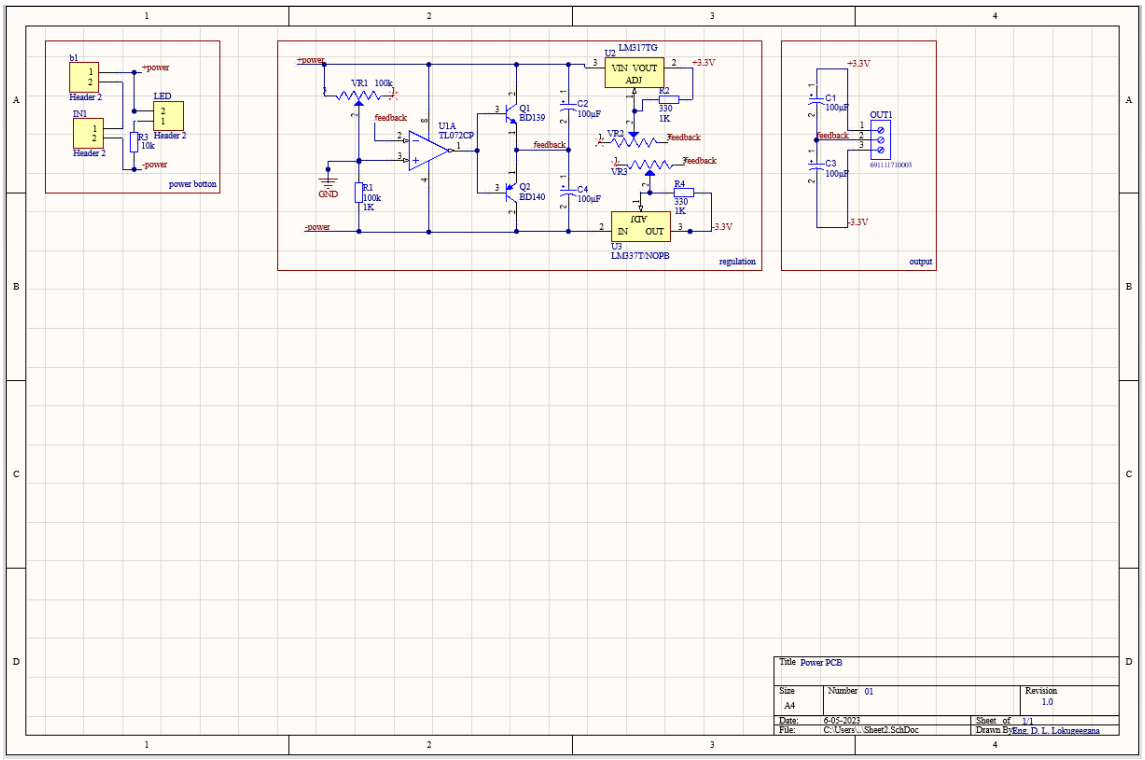

Figure 29 selected schematic sheet 4

Chapter 3 – preliminary report

Schematic and Solidworks

Power circuit Schematic

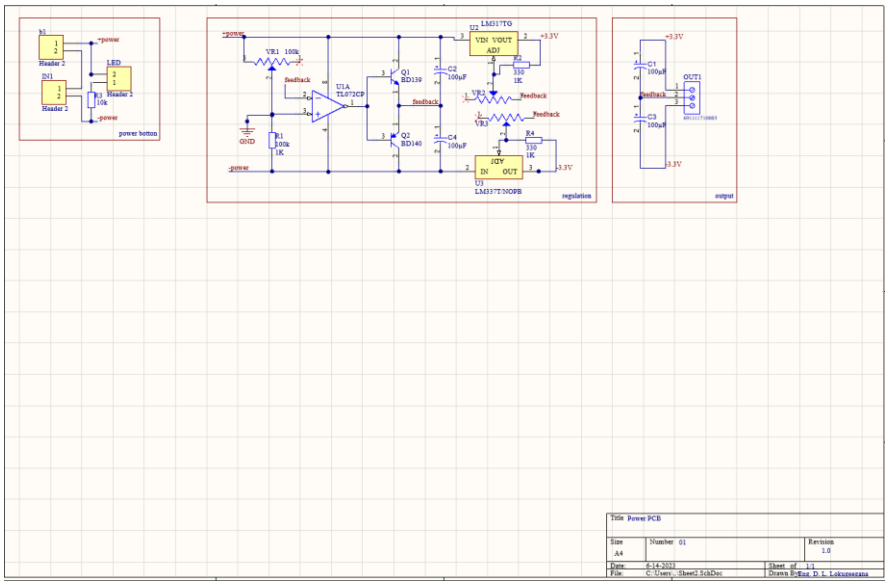

Figure 30 power circuit schematic

Main PCB Schematic

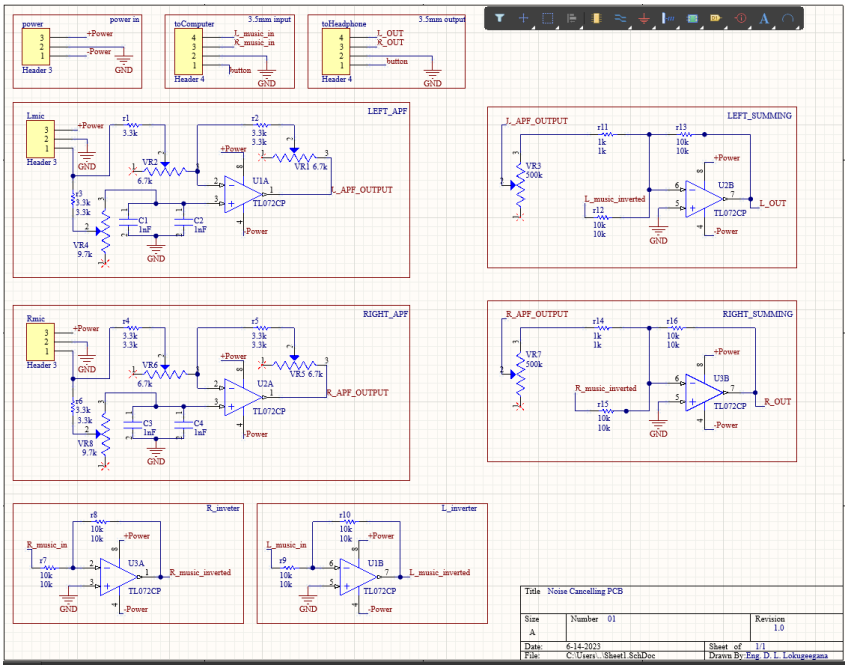

Figure 31 main circuit schematic

Implemented SolidWorks

Lower Part

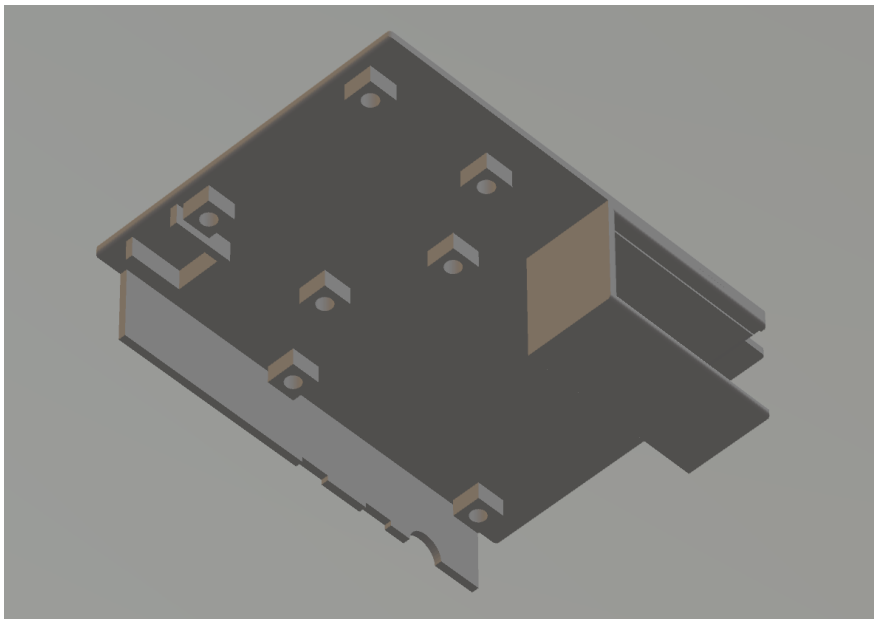

Figure 32 printed encloser lower part

Upper Part

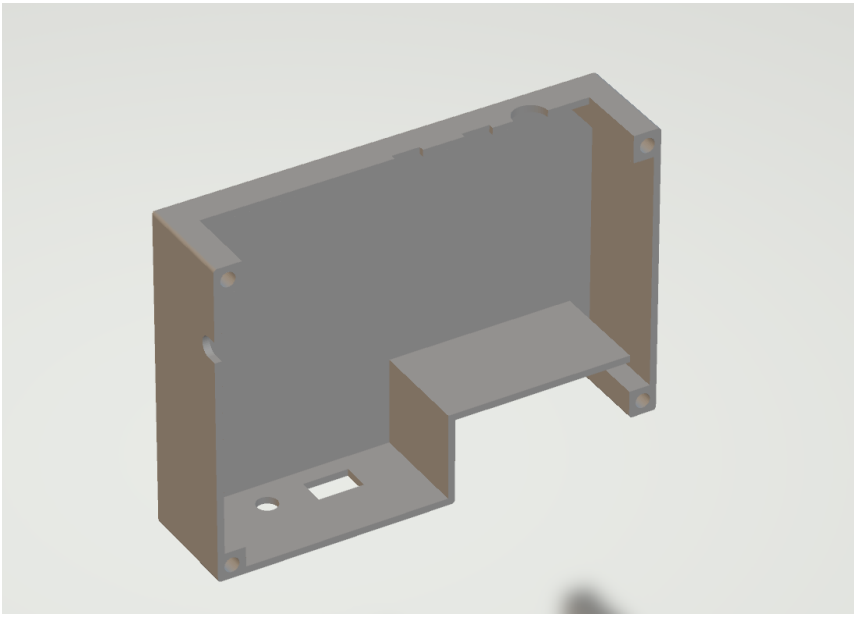

Figure 33 printed encloser upper part

Ear part

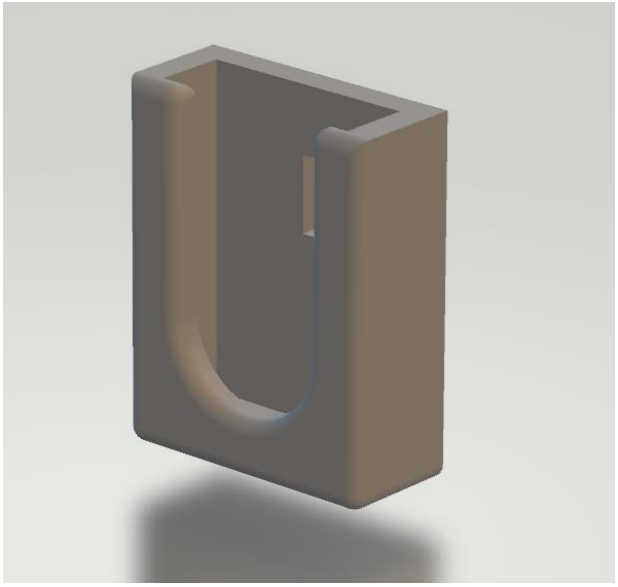

Figure 34 printed encloser ear part

Battery lid

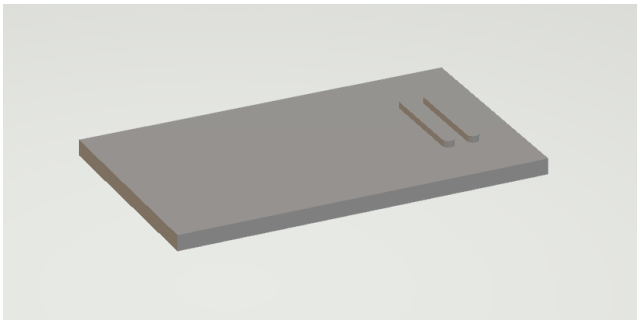

Figure 35 printed encloser battery lid

Problems Identified

1. Schematic is not done in professional manner.
    a. Status box filling.
    b. Naming components from top to bottom for eazy identification.
    c. Minimizing usage of wires (instead use net labels).

2. Encloser moldability
    a. Draft angle analysis.
    b. Design in a way which can be moldable.
    c. Injection molding process.

3. Appearance for marketing
    a. Importance of final appearance for marketing.
    b. Attractiveness by colour and texture.

4. User need analysis
    a. Take user feedback for better product implementation.
    b. User feedback analysis methods.

5. Design cycle implementation
    a. How to do proper design.
    b. How the product gets improved by design cycles.

6. Product manual and documentation
    a. User manual.
    b. Maintenance manual.
    c. How to keep proper and complete documentation.

Problems and Improvements Provided by Group Members

Problems Identified

1. Size (how to make small as possible)
2. External wire minimization.
3. Analog circuit accuracy.

Improvements

1. Using Mics in the device to capture noise.
2. Digital noise cancelling circuit.

Problems and Improvements Provided by Users

Problems Identified

1. Size (how to make small as possible)
2. Attractiveness.
3. External wire minimization

Improvements

1. Using Mics in the device to capture noise.
2. Make it more user-friendly shape.

Chapter 4 – detailed design

Block diagram

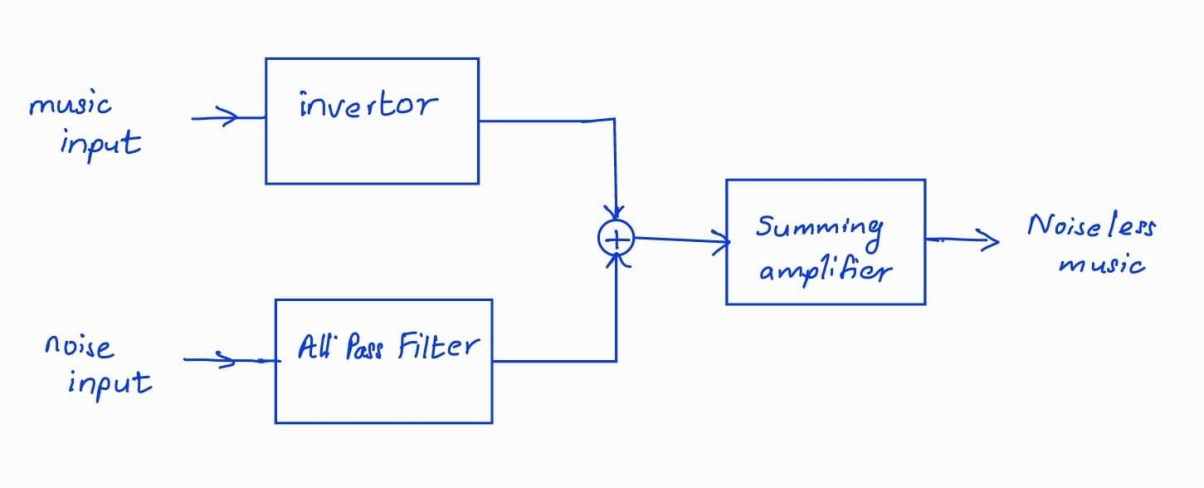

Figure 36 detailed design basic block diagram

Circuit

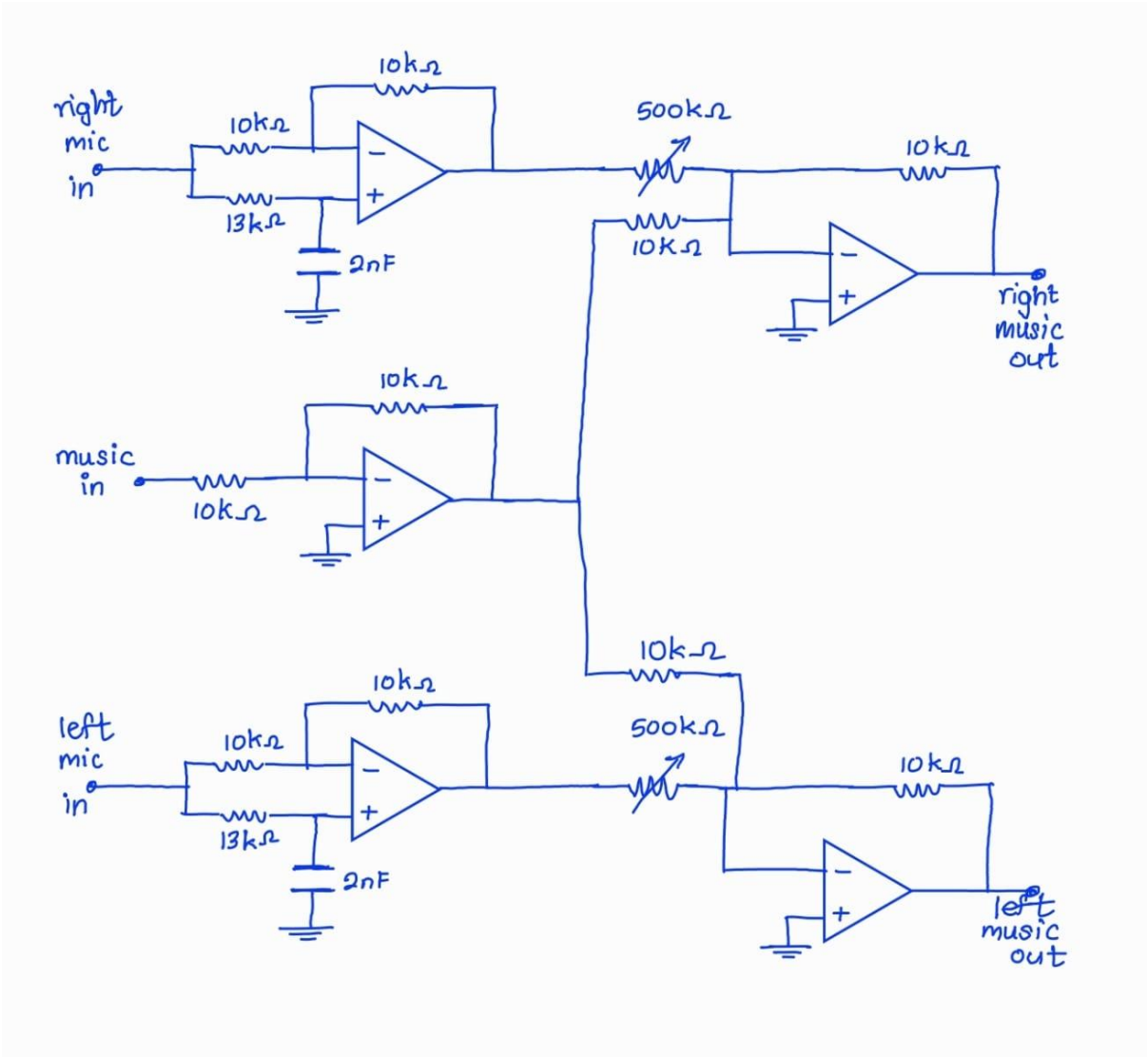

Figure 37 detailed design circuit

Altium design

Main Schematic

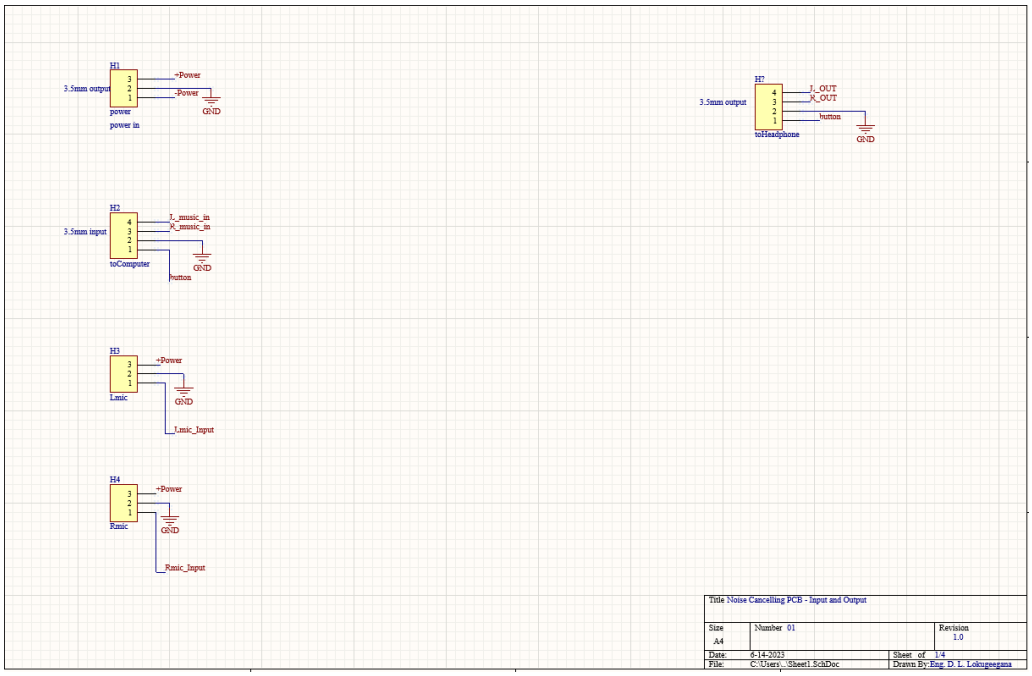

Figure 38 detailed design schematic sheet 1

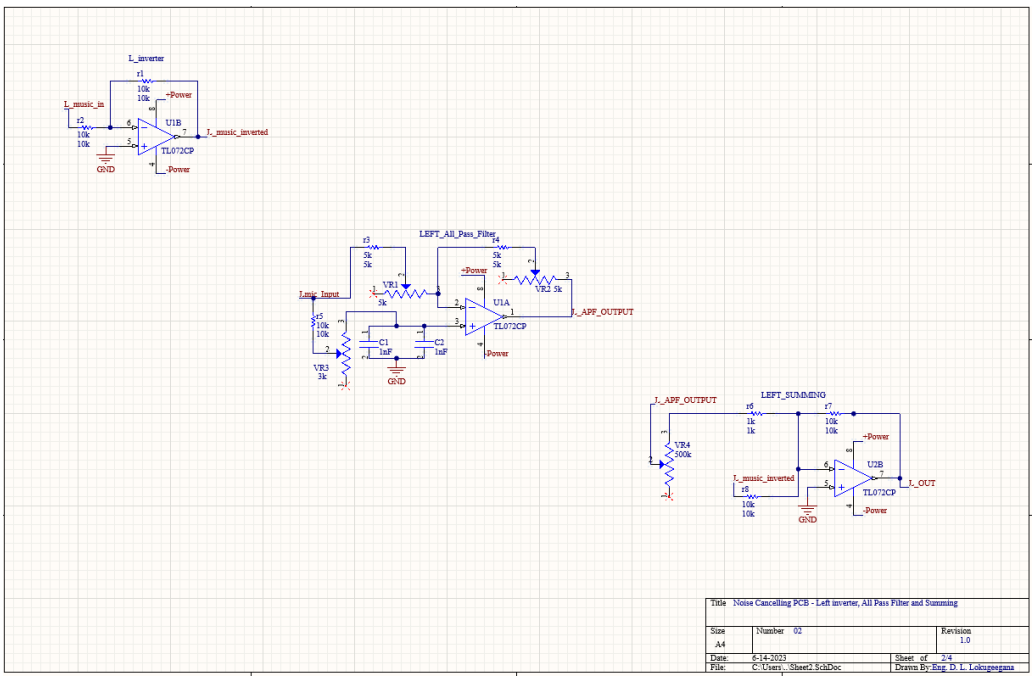

Figure 39 detailed design schematic sheet 2

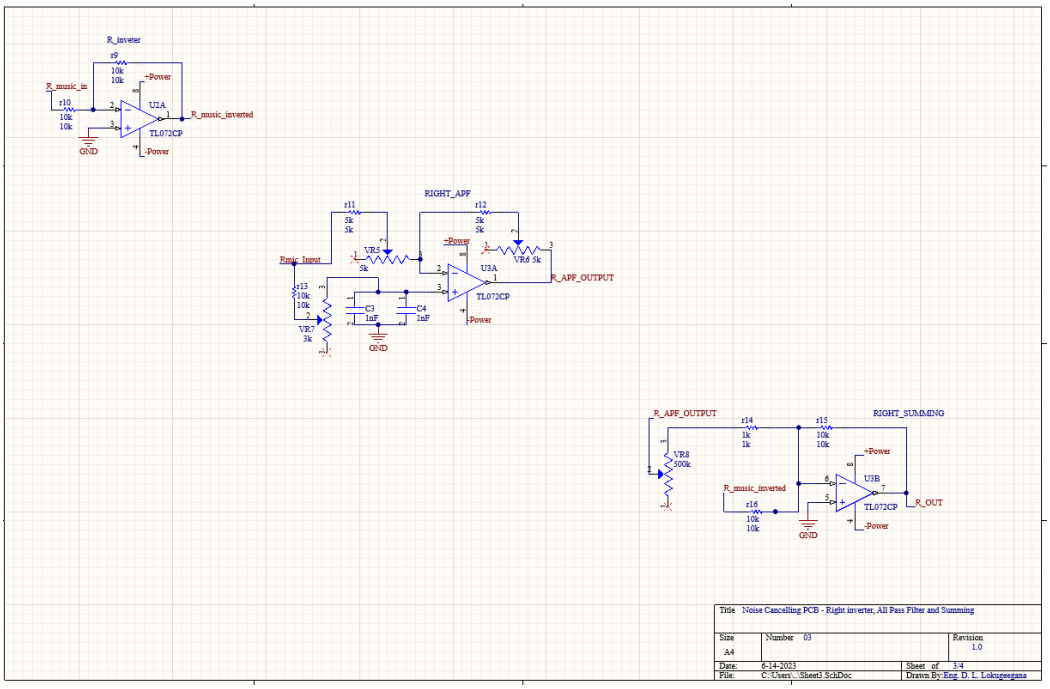

Figure 40 detailed design schematic sheet 3

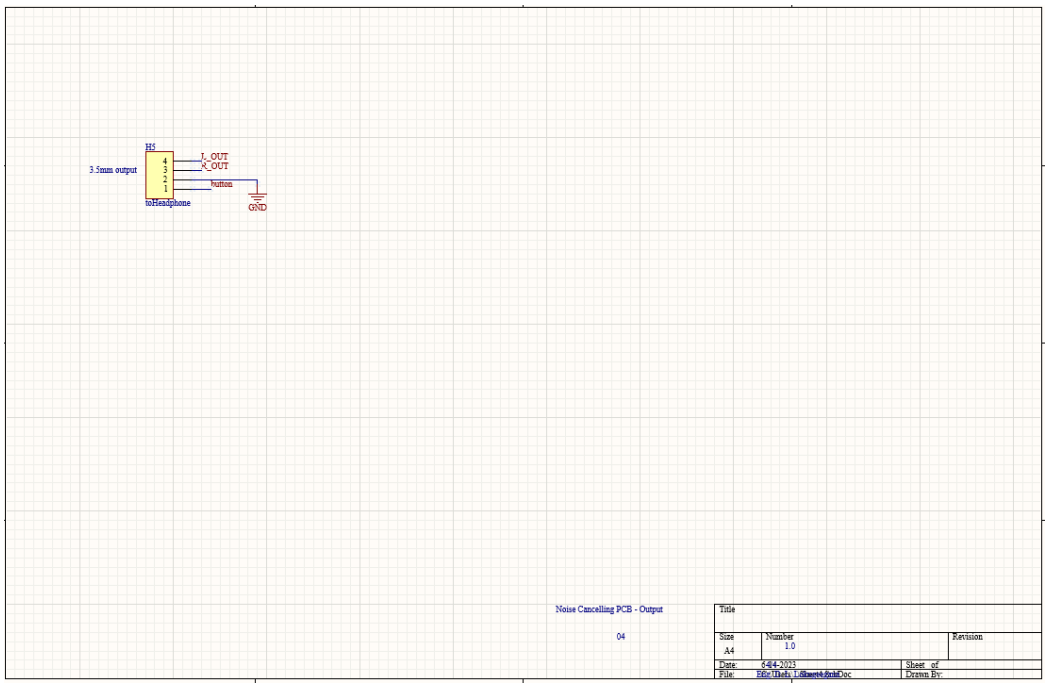

Figure 41 detailed design schematic sheet 4

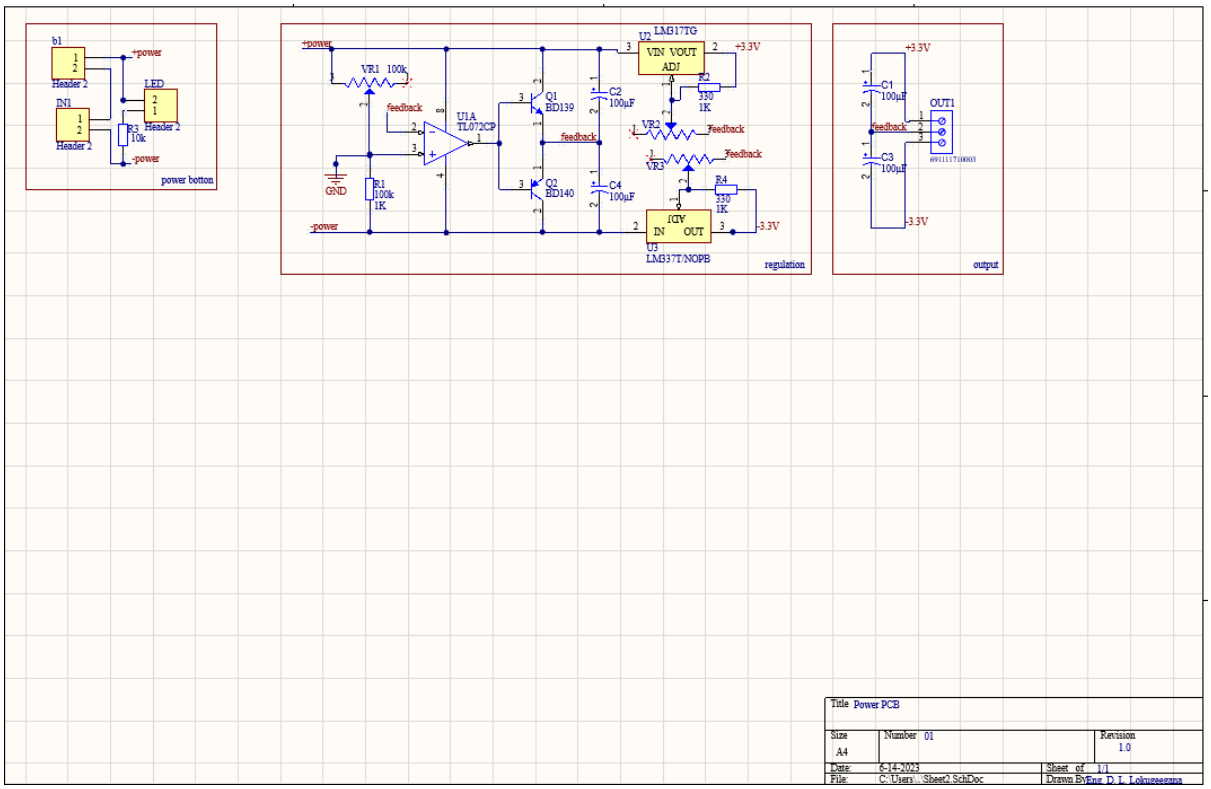

Figure 42 detailed design power circuit schematic sheet

PCB

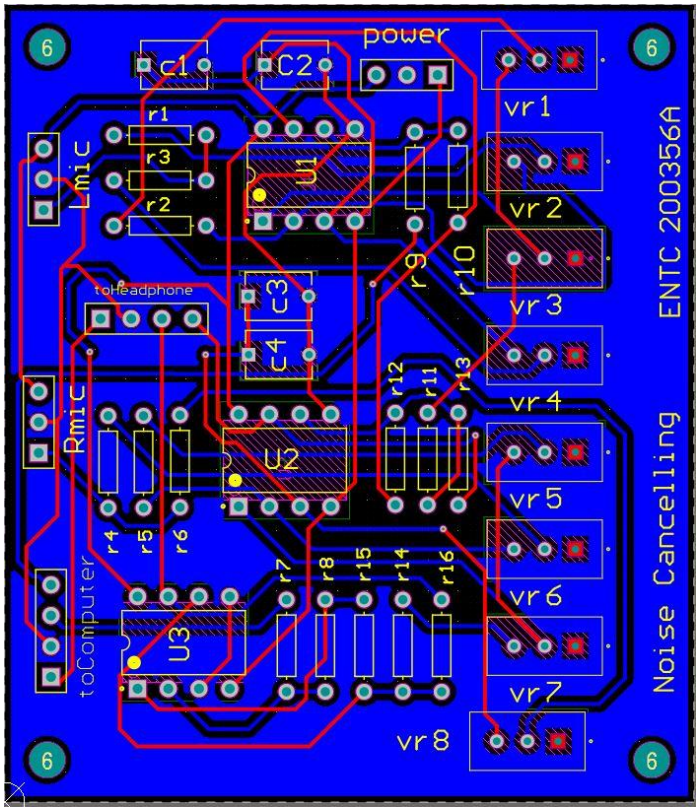

Figure 43 main PCB altium

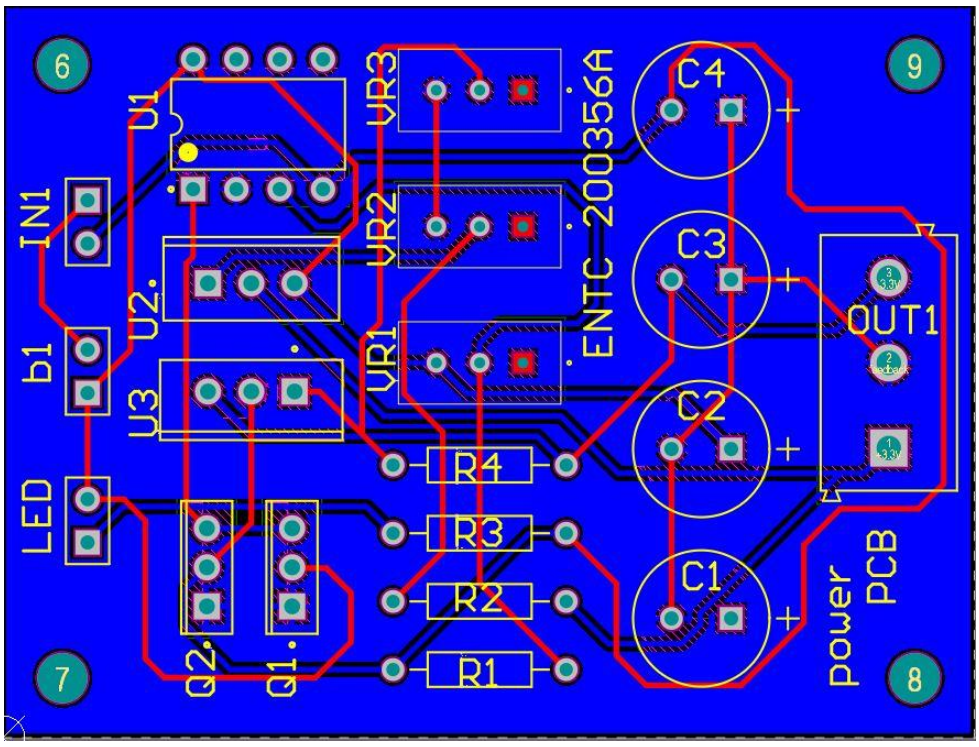

Figure 44 power PCB altium

Gerber file details

Noise cancelling PCB

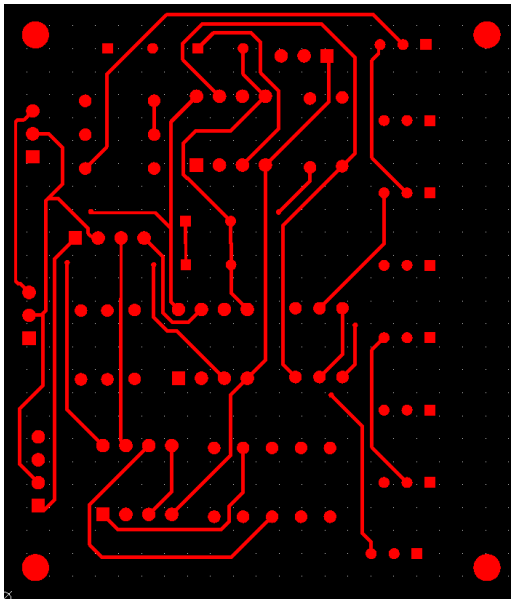

Figure 47 Top layer Gerber data

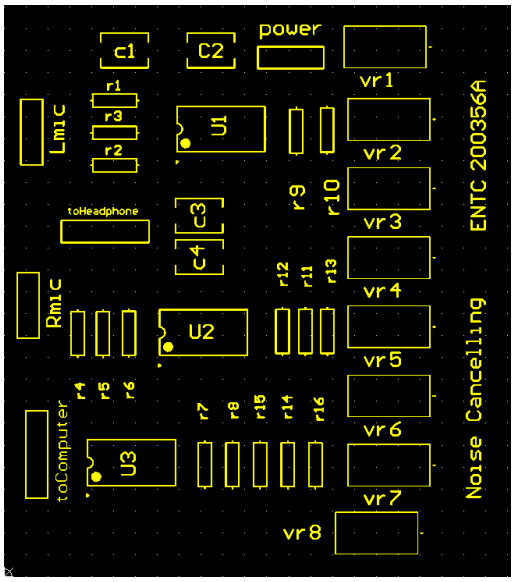

Figure 46 Top overlay Gerber data

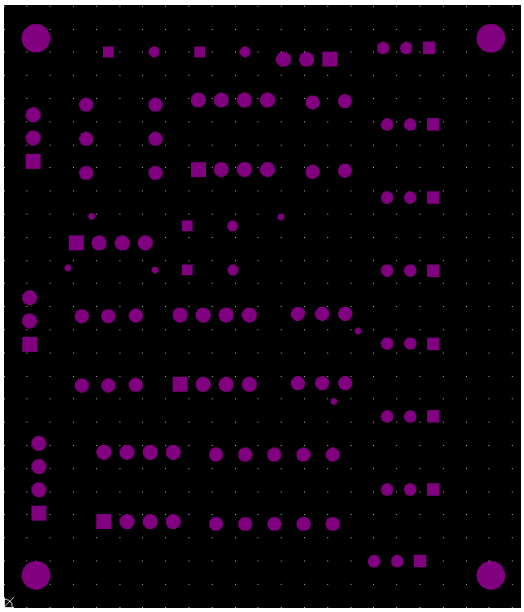

Figure 48 Top soldier mask Gerber data

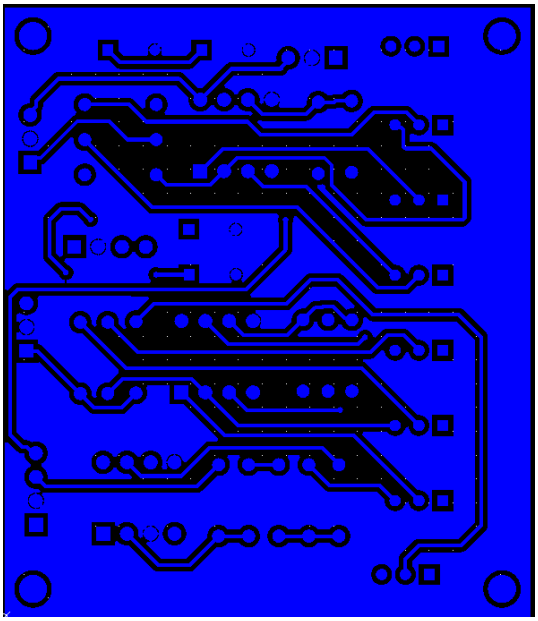

Figure 45 Bottom layer Gerber data

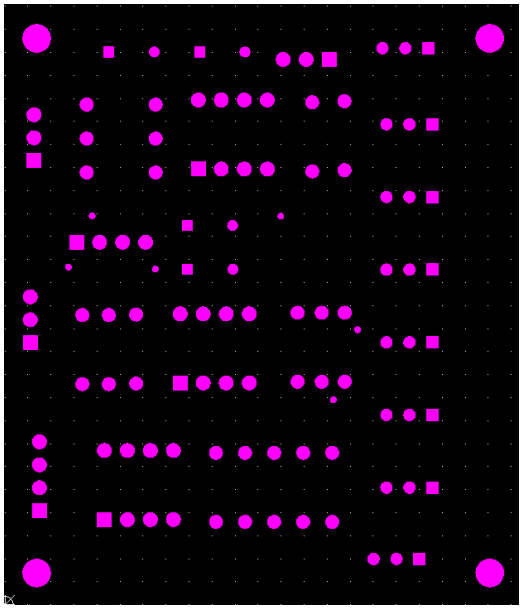

Figure 50 Bottom soldier mask Gerber data

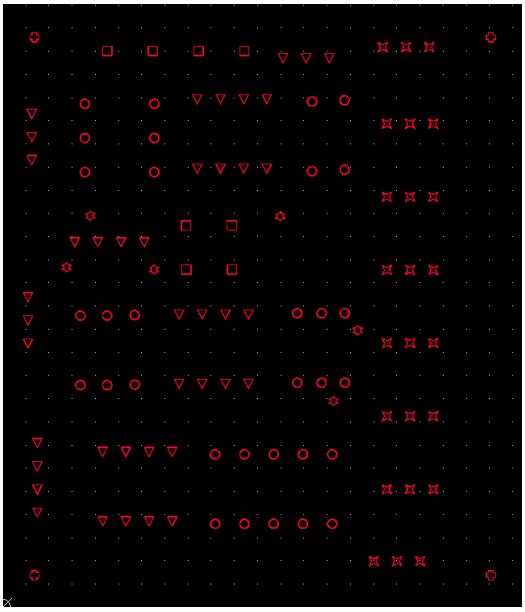

Figure 49 Drill drawing layer pair Gerber data

Power PCB

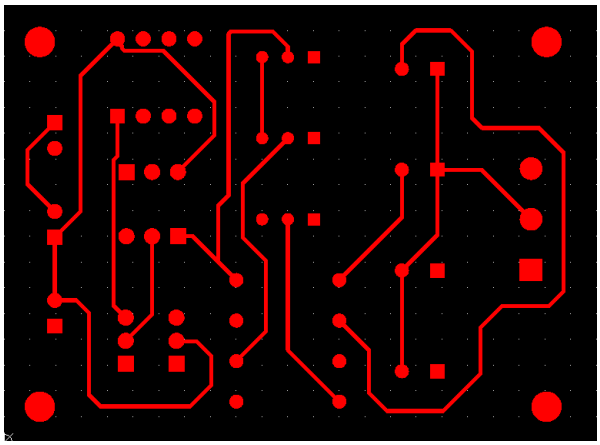

Figure 55 Top layer Gerber data

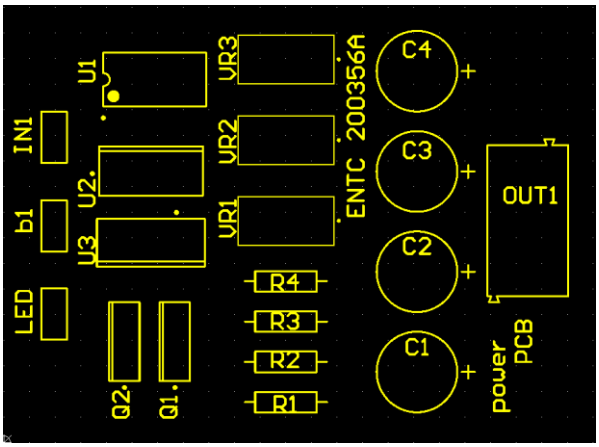

Figure 53 Top overlay Gerber data

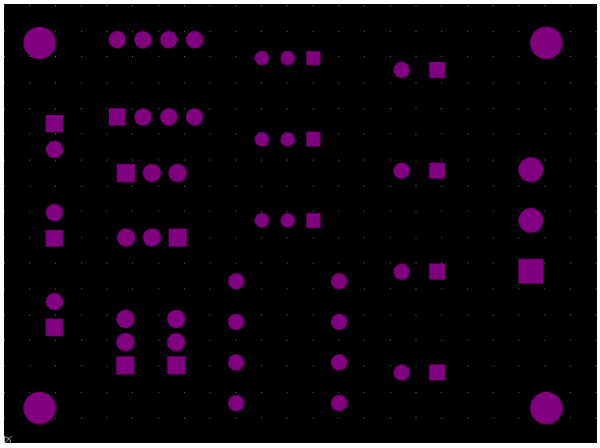

Figure 52 Top soldier mask Gerber data

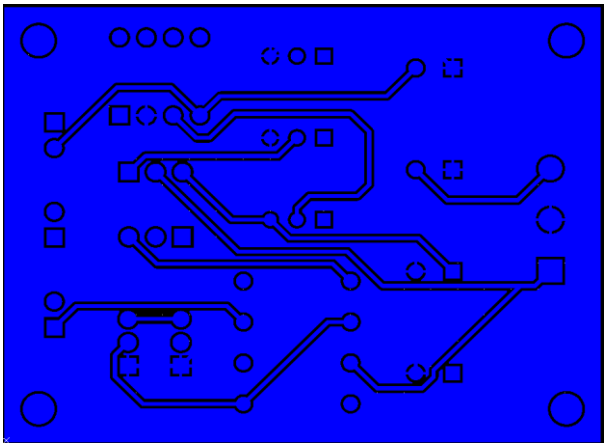

Figure 51 Bottom layer Gerber data

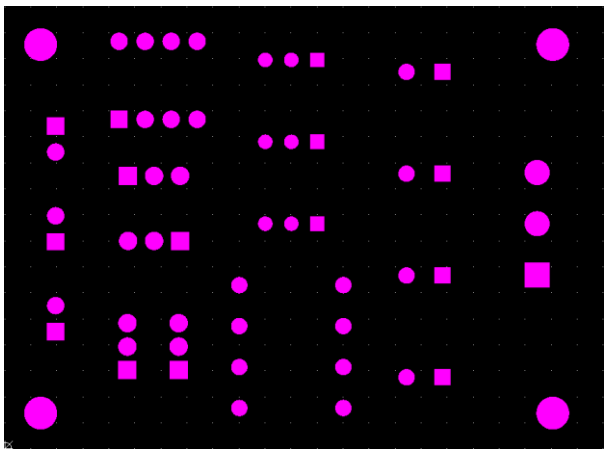

Figure 54 Bottom soldier mask Gerber data

Images of PCB after soldering and after first testing

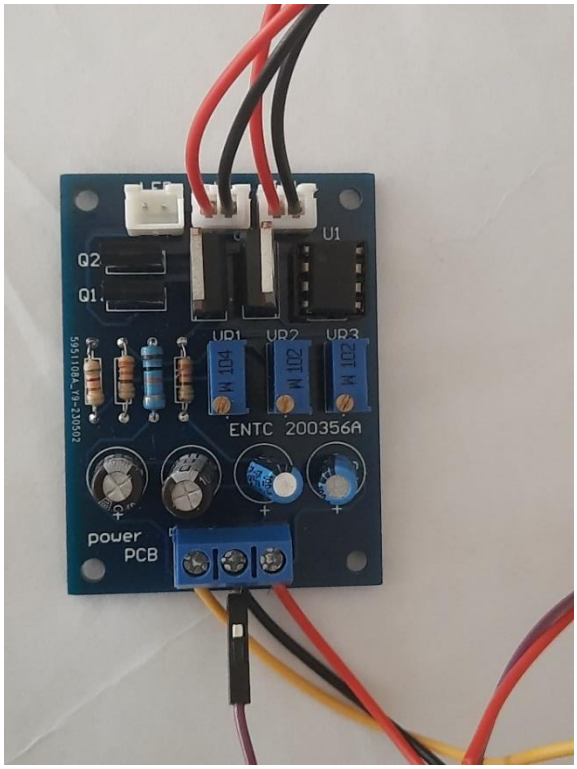

Figure 57 power PCB after soldering

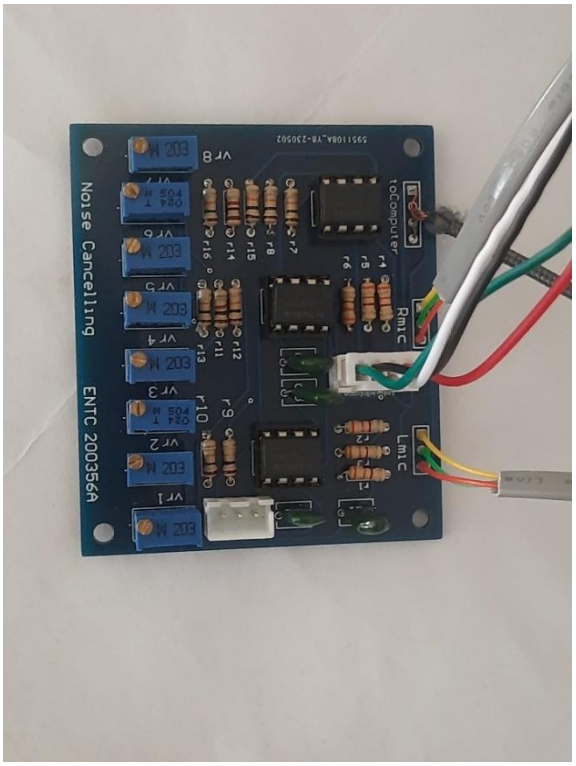

Figure 56 Noise cancelling PCB after soldering

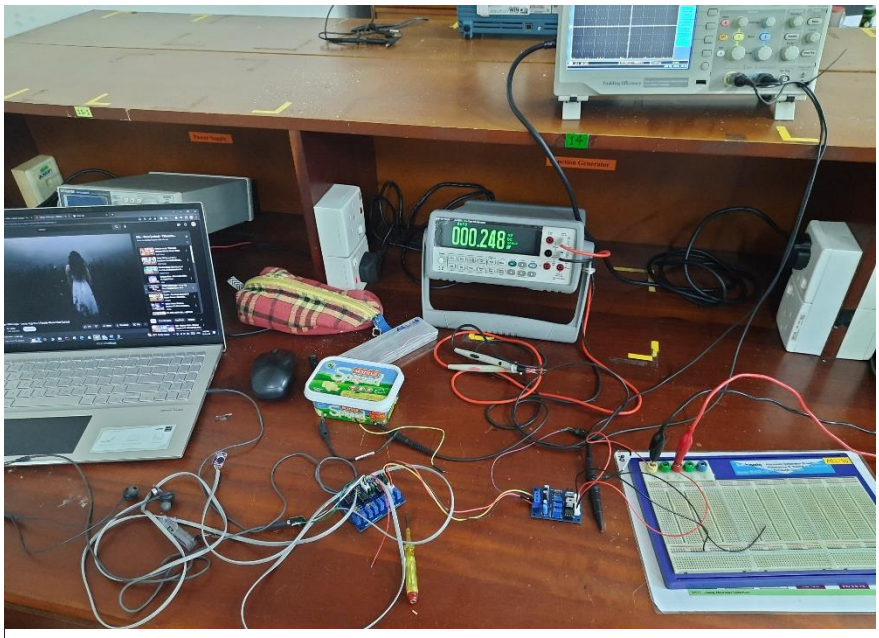

Figure 58 implementation

Encloser

Enclosers are going to be made using injection molding for mass scale and it is 3D printed for the prototype.

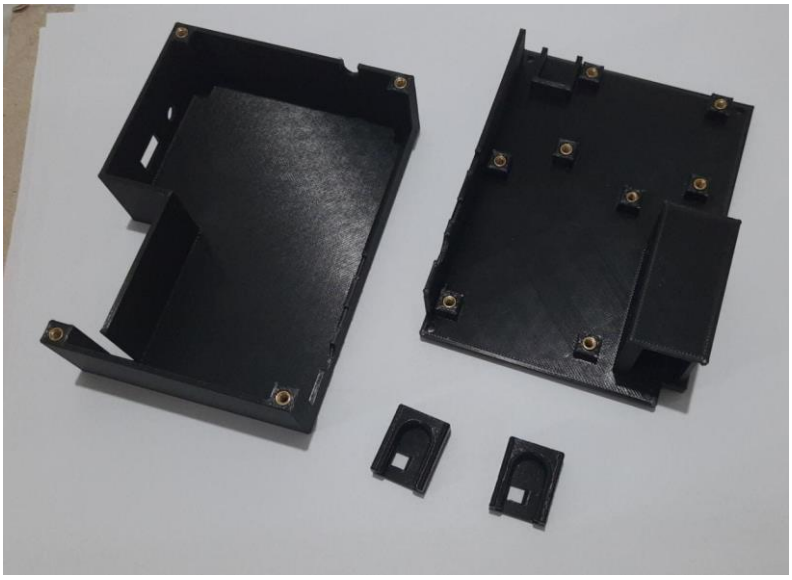

Figure 59 encloser uncombined

Figure 60 encloser combined

Chapter 5 – Manufacturing

PCB fabrication process

There are 2 main PCBs both are 2-layer PCB. Power PCB is converting 9V input to +3.3V and -3.3V outputs.

Both PCB fabrication process is outsourced to reduce cost

and get high quality.

PCB Manufacturer: Jia Li Chuang (Hong Kong) Co., Limited (JLC PCB)

Noice cancelling PCB

Base material – FR-4

Dimensions - 57mm x 66mm

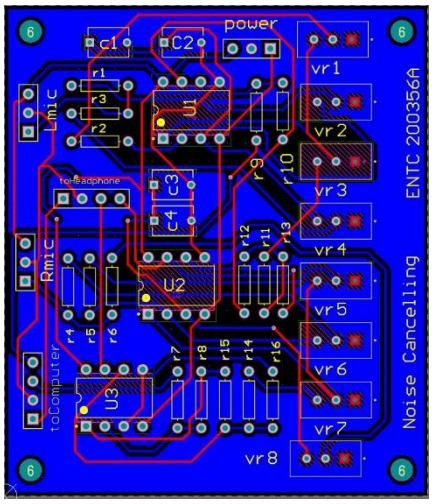

Figure 61 Noice cancelling PCB

Power PCB

Base material – FR -4

Dimentions – 57mm x 43mm

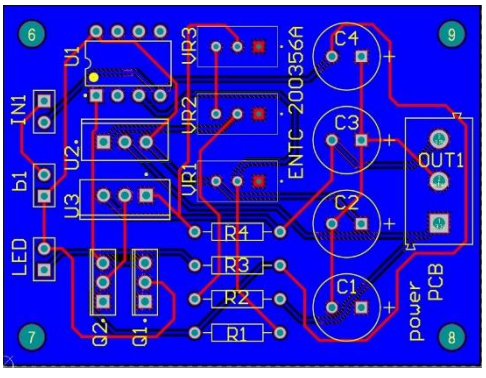

Figure 62 power PCB

BOM

No	Manufacture part no	Description	Quantity	Price	Supplier
1	https://www.smart-prototyping.com/MAX4466-Electret-Microphone-Amplifier-Module	Max 4466 sensor	2	830	Smart prototyping
2	https://tronic.lk/product/telephone-cable-4-wire-per-meter	Telephone cables	1m	80	Local supplier
3	https://tronic.lk/product/5-pin-headphone-jack-pcb-mount-female-3-5mm-stereo	3.5mm audio jack	1	90	Local supplier
4		4pin JST	1	60	Local supplier
5		3pin JST	1	90	Local supplier
6		2pin JST	2	40	Local supplier
7		3.5mm audio cable	1	350	Local supplier
8		LED	1	10	Local supplier
9		Power button	1	40	Local supplier
10		9V battery connector	1	80	Local supplier
11		100uF cap	4	20	Local supplier
12		3way connector	1	40	Local supplier
13		330Ω	2	10	Local supplier
14		10kΩ	9	45	Local supplier
15		100kΩ	1	5	Local supplier
16	https://www.mouser.com/ProductDetail/Texas-Instruments/TL072CP?qs=5nGYs9Do7G3e6Tx9uHIgUA%3D%3D	TL072cp	4	1350	Mouser electronics.
17	https://www.mouser.com/c/?q=BD139	BD139	1	220	Mouser electronics.
18	https://www.mouser.com/c/?q=bd140	BD140	1	245	Mouser electronics.

19	https://www.mouser.com/ProductDetail/Texas-Instruments/LM317KCS?qs=Zu35EjizYSTLhqY3lVz7nA%3D%3D	LM317	1	290	Mouser electronics.
20	https://www.mouser.com/ProductDetail/TexasInstruments/LM337KCSE3?qs=iSMark9AYDWpc5pQ5gDgRw%3D%3D	LM337	1	350	Mouser electronics.
21		10kΩ var. resistor	8	320	Local supplier
22		100kΩ var. resistor	1	40	Local supplier
23		500kΩ var. resistor	2	80	Local supplier
24		1kΩ	2	10	Local supplier
25		3.3kΩ	6	30	Local supplier
26		1nF	4	20	Local supplier
	Total cost of material			7445	

Mass production encloser cost – 200

Soldiering cost – 200

Total cost – Rs 7845

Estimated selling price is 10000

Chapter 6 – results and conclusion

Noise cancelling is only to a certain level. Problem is with the noise capturing mics. These mics are not sensitive enough to capture all the noise heard.

Product can be made in mass scale if encloser is molded instead of 3D print.

Product encloser is to be changed to be more attracted while PCBs can be reduced in size by using surface mounting components in mass production.

Figure 63 final product

Chapter 7 - User manual

Initializing

1. There are two gray colour wires which contains the microphone user have to fix them to the headphone as in the below image.

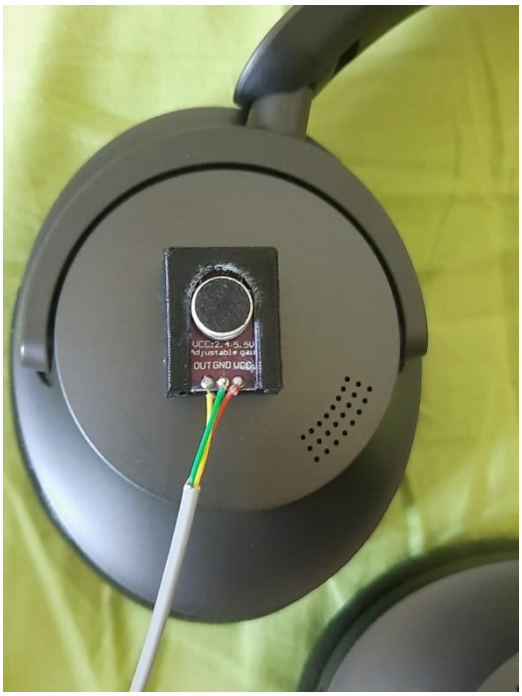

Figure 64 mic attach

2. There is a printed attachment tape on the mic so that the user can identify which mic should be attached to which sided of the headphone. **This is a very important step.**

R is to the right

L is to the left

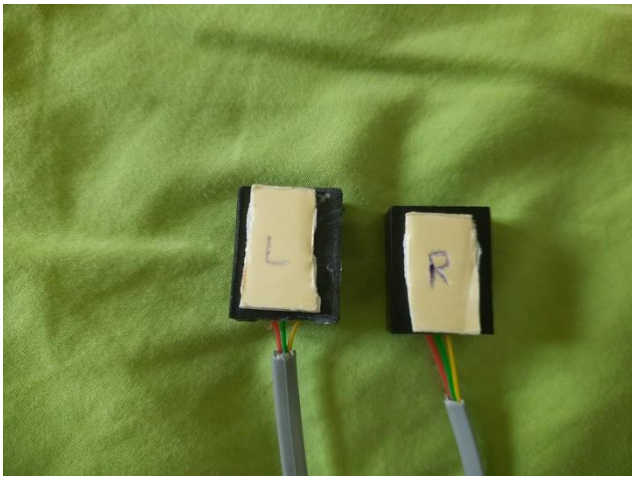

Figure 65 mic attachment side identify

Using

1. After doing the initializing steps user can plug the 3.5mm wire to the device.

Figure 66 plug adapter to device

2. Then user can plug the headphone 3.5mm jack to the 3.5mm port in the adapter.

Figure 67 plug headphone to adapter

3. The listen to the music by switching on the device which will be indicated by a red LED.

Figure 69 before switching on

Figure 68 after switching on

Battery changing

Battery lid needs to be slide to the left as shown in the figure.

Figure 70 battery lid slide direction

Them change the 9V battery and closed the lid again.

Figure 71 battery lid open

Bibliography

[1] Sbacilico, "Analog Noise cancelling Headphone," AUTODESK Instructables, [Online]. Available: https://www.instructables.com/Analog-Noise-Cancelling-Headphones/. [Accessed 11 03 2023].