University of Moratuwa
Faculty of Engineering
Department of Electronic & Telecommunication Engineering

EN1190 - Engineering Design Project

Team Strawhats
Portable Bluetooth Audio Splitter

Group Members

Index Number	Name
230145E	Dilhan W.A.
230256U	Ilankoon I.M.M.K.B.
230258D	Imaduwage O.N.H.
230544C	Rathnayake M.A.G.K.N.

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1 Problem Description

1.1 Problem

Entertainment is typically a shared experience — whether it's listening to music or watching a movie, it's always better experienced together than alone. Typically, this is achieved using the built-in audio output system of a device (such as a phone, TV, or tablet) with the help of a speaker.

Most devices we typically use in day to day life come with built-in speaker systems to allow us to share entertainment with ease. However, this approach has its limitations.

The usage of speakers is not feasible in most public spaces, and their use comes with the loss of privacy and a general disturbance to people in the vicinity. In such situations, using earphones is a conventional solution - with the world largely shifting to adopt the large-scale use of wireless earbuds.

Unfortunately, there is no existing cheap and accessible technology allowing the connection of multiple wireless earbuds together.

1.2 Expectations

We aim to create a solution that seamlessly pairs Bluetooth audio from a digital device to several wireless earbud pairs, while supporting a wide range of Bluetooth devices.

1.3 Our Solution

Our device functions as a wireless Bluetooth splitter connecting multiple devices simultaneously. The user first pairs their mobile phone (or any other appropriate Bluetooth output device) and then pairs up to 4 Bluetooth earbuds, allowing them to hear seamless audio streams at once.

1.4 Justification and Alternatives

Newer Bluetooth technologies in the form of "AuraCast" now support multiple Bluetooth audio streams simultaneously. While the usage of such chips in modern phones greatly increases efficiency and ease, the cutting edge technology lacks support for a wide range of devices, outside of flagship models. This presents an evident issue, since the problem of Bluetooth broadcasting requires solutions that support all devices.

MercAp, our wireless Bluetooth splitter, relies on standard Bluetooth chips - therefore allowing for support of all types of Bluetooth audio output devices.

MercAp currently supports up to 4 Bluetooth earbuds. This number of devices was validated through our market evaluation, confirming both the need for this device and the lack of an effective alternative on the market.

2 Product Feasibility

Our solution had certain requirements:

- Share audio simultaneously to multiple earbuds
- Support all current and legacy Bluetooth audio standards
- Easy setup and seamless connection
- Small, handheld and light
- Battery life of at least 2 hours

We used KCX-BT v1.4 Bluetooth Audio transceiver modules to provide the audio input and outputs for our device. We opted for analog audio noise filtering, due to the lower cost and ease of building a compact device. We used two 3.7V rechargeable Li-Ion batteries, with a center tapped configuration to power our chips as necessary. We also utilized LED lights as indicators for connectivity.

The KCX-BT Emitter modules use Bluetooth Version 5.2, enabling backwards compatibility with legacy standards, and were capable of providing seamless audio to multiple connected earbuds. The LED indicators and switches used allowed for simpler user connection setup. With an enclosure of 12.8 x 12.8 cm and a battery life estimated at 10 hours, we consider our device successfully portable.

Hence, we believe we have made a feasible prototype solution.

3 Design Deviations and Future Improvements

Due to cost constraints and restrictions of chip availability, the two options for Bluetooth transceivers were ESP32-WROOM-32UE or the KCX-BT v1.4 Module.

The usage of the ESP32 to act as Bluetooth transceivers was replaced with the KCX-BT Emitter Modules for the following reasons:

- ESP32 Chips are costly
- ESP32 Chips have significantly higher power consumption, and jeopardized battery life
- High noise and interference in signals
- ESP-32 usage would require the usage of either the built in DAC (low quality 8-bit sound) or an external DAC (higher power consumption, complex digital PCB design)

Additionally, other initial considerations like the built-in speaker or flashlight were discarded due to redundancy.

The major areas for improvement are the lack of stability in the Bluetooth connections. Our device could only maintain stable connections between 2 pairs of earbuds, additional connections were unreliable. We attribute this to the lack of customizability in the KCX-BT Modules' programming. Altering the frequency range of each module or modifying their MAC Addresses to avoid overlap would likely improve reliability.

Another area of improvement would be noise filtering. While the analog noise filtering and buffering functioned optimally, small defects in the transceiver module led to inaudibility in the Right Channel during transmission. We can attribute this to either soldering defects or chip defects, due to the complexity of castellated hole soldering by hand. Opting for PCBA methods would likely overcome this issue.

In conclusion, the major bottleneck of the design is evidently the transceiver chip used. Using alternatives like the NXH3675 chip, the NXH3670 chip or the IDC777 chip would likely solve the prototype's issues.

4 Functionality

The designed operation of the MercAp device relies on connection of one Bluetooth audio output device (IE. a mobile phone or laptop) and four Bluetooth earbuds. Furthermore, the device features switches to allow the user to limit the number of Bluetooth earbuds being connected as required.

5 Device Specifications

- Weight: 200g
- Dimensions: 12.8 x 12.8 x 4 cm
- Bluetooth Capability: Version 5.2 with backwards compatibility
- Range: 20m
- Audio Dynamic Range: 80dB
- Power Consumption: 1.1W
- Battery Life: Up to 10 hours on a single charge

6 Product Architecture

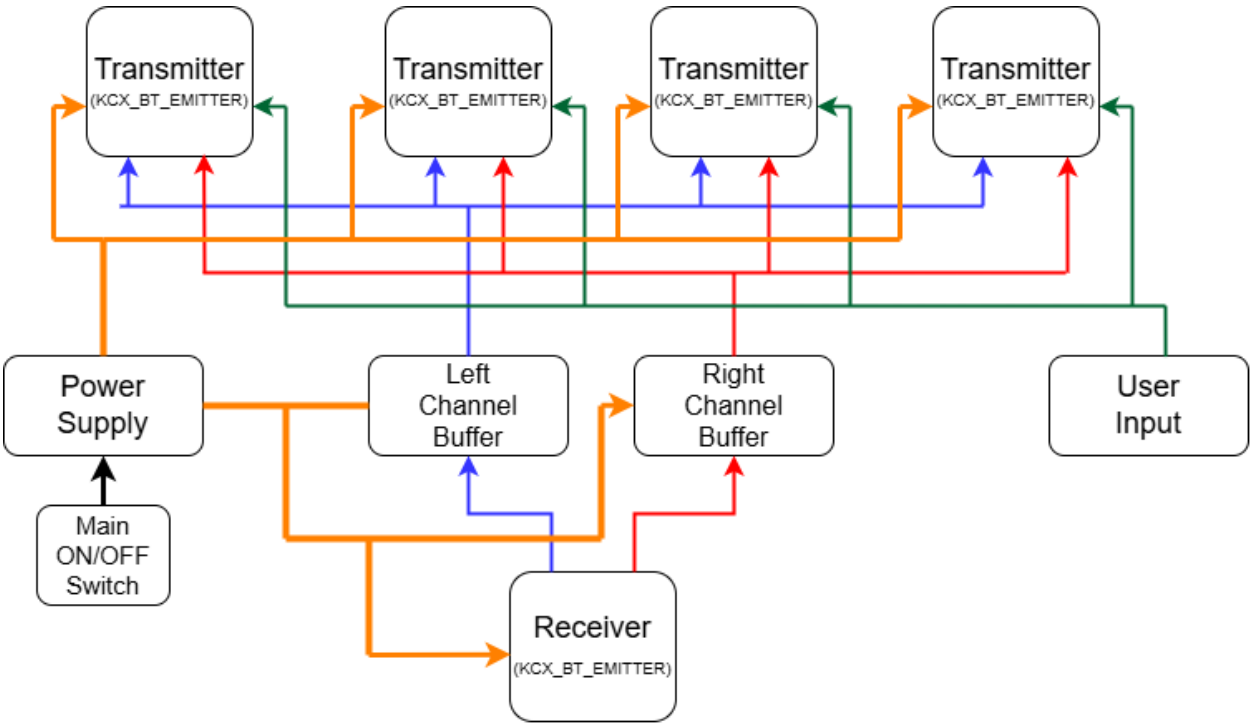
KCX-BT Emitter Module - This is a wireless Bluetooth audio transceiver module that integrates stereo audio transmission and reception

Left/Right Channel Buffer - This is an audio buffer and noise filter for either audio channel, comprising of an Op-Amp in Unity Gain Buffer mode, and several noise filtering capacitors

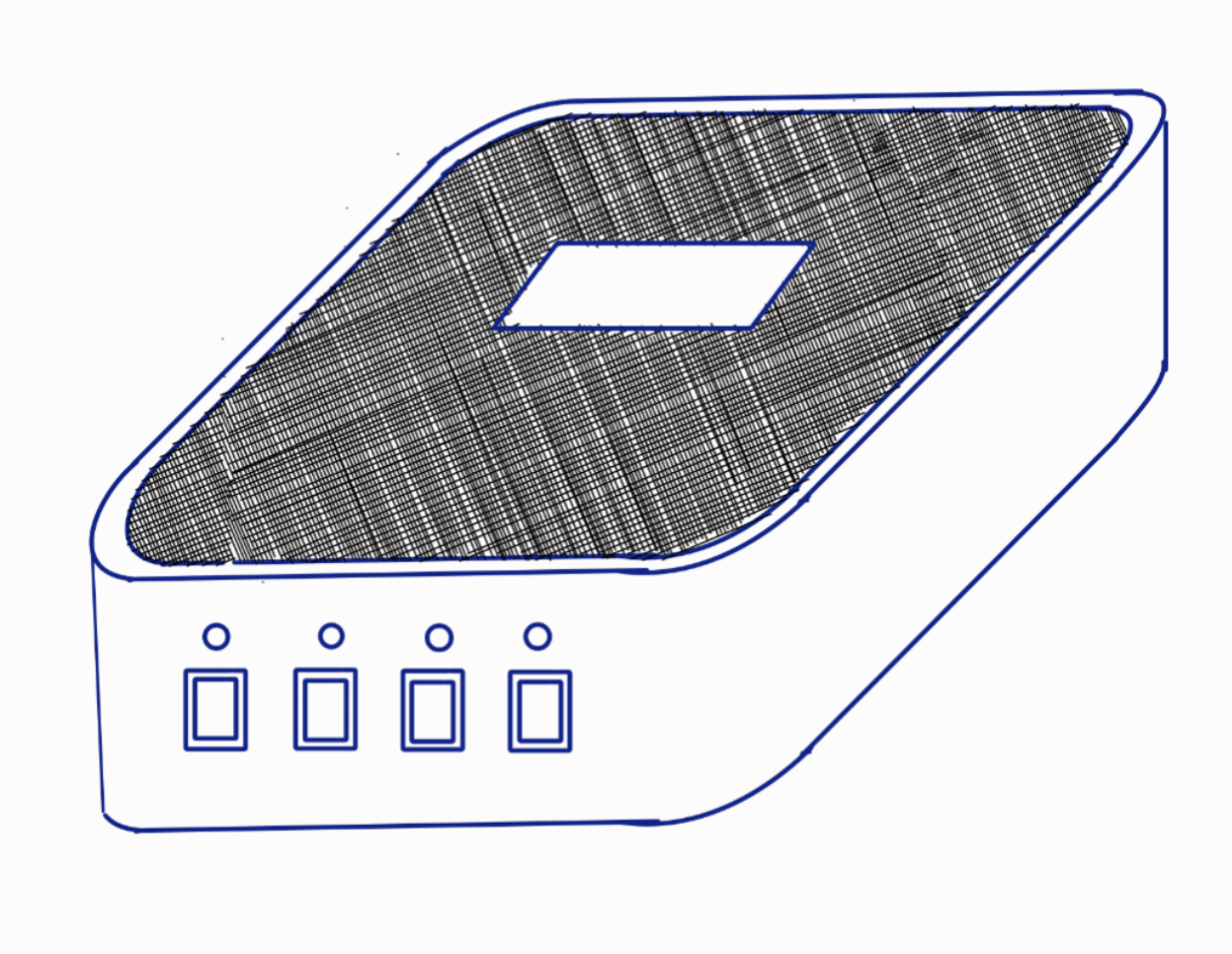
NE5532 Operational Amplifier - This is used to buffer and split the analog audio streams without losing the fidelity

Power Supply - This provides 7.4V, split into two power rails at +3.7V and -3.7V with a common ground; using two 3.7V 3200mAh Li-Ion batteries.

6.1 Block Diagram



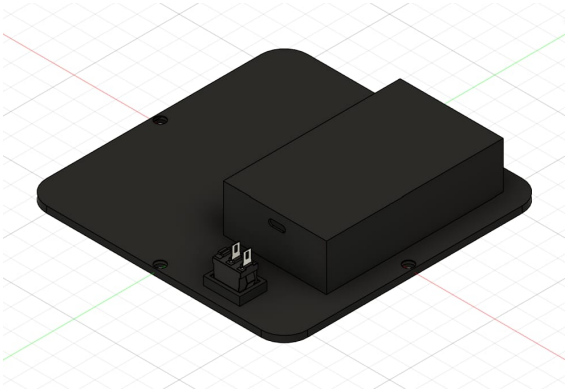
6.2 Initial Sketch



6.3 Final Enclosure

(a) External View

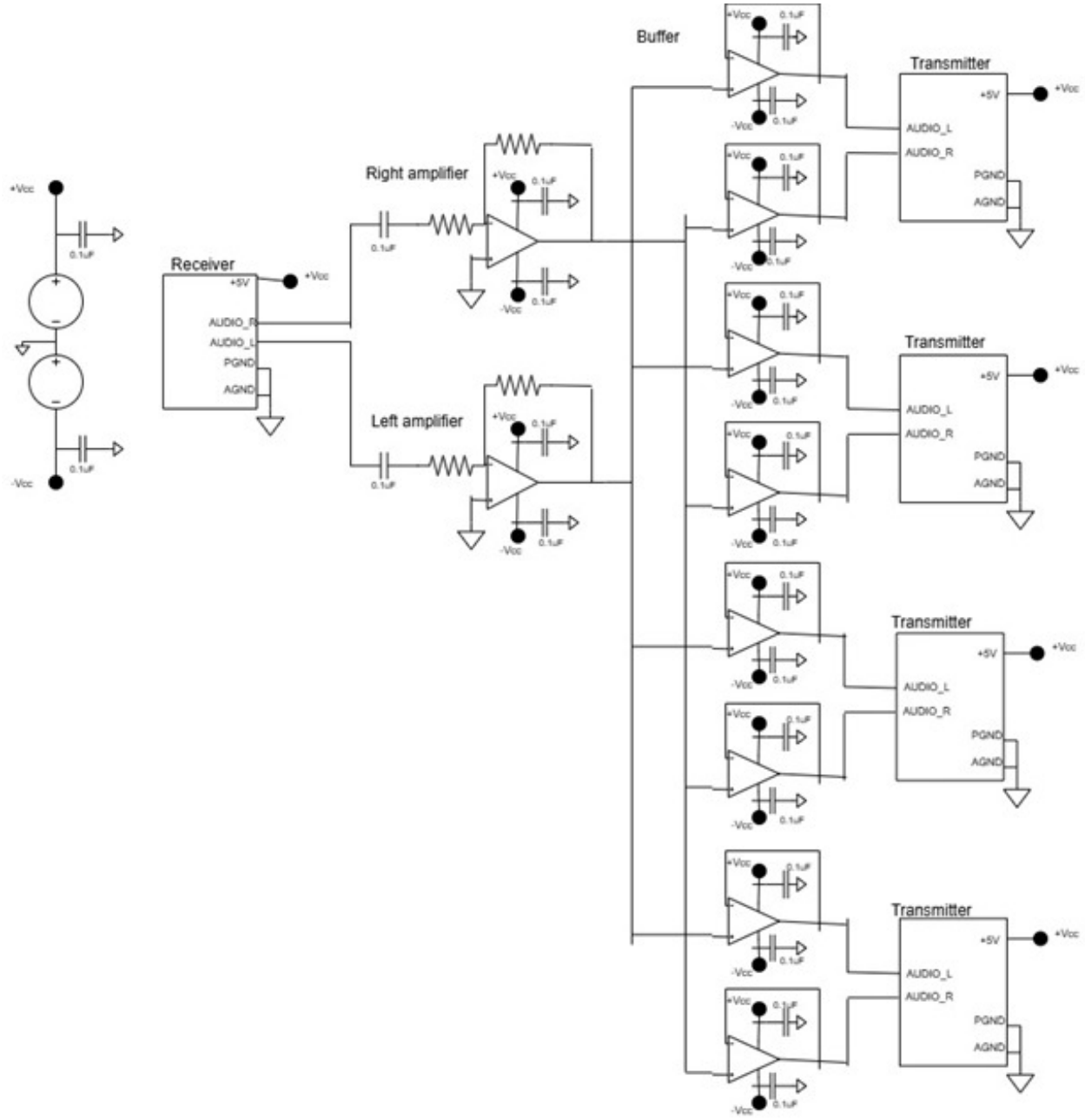
(b) External View



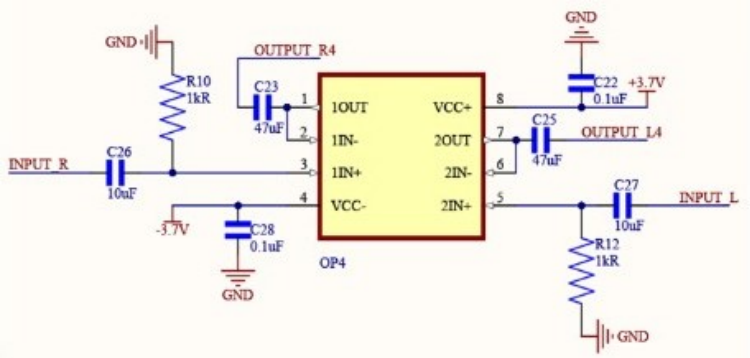
(c) Internal View

6.4 PCB Design

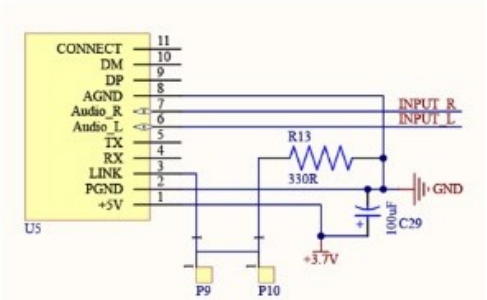
6.4.1 Circuit Diagram



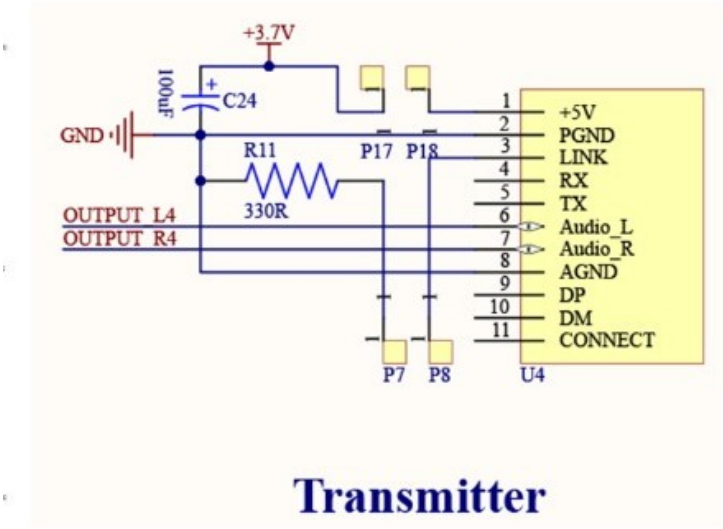
6.4.2 PCB Schematic



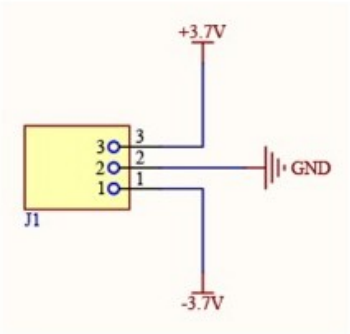
Operational Amplifier Buffer/Splitter



Bluetooth Reciever

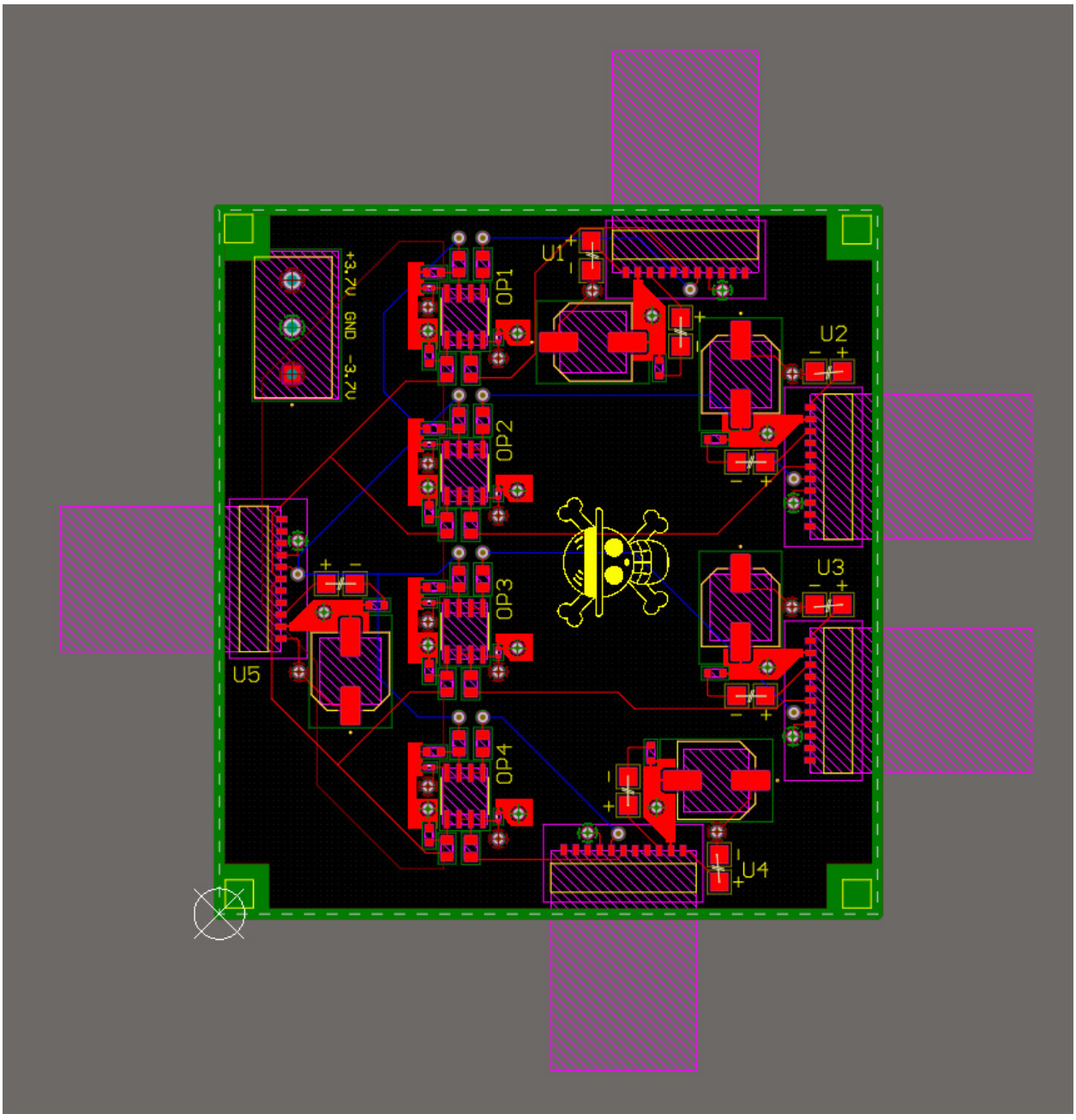


Transmitter



Split-Rail Power Supply

6.4.3 Final PCB Layout



6.5 Final Product

7 Market Analysis

Before designing the product, our team performed a market evaluation in order to determine the following criteria:

1. Problem Validation
2. Overall interest in the solution provided by our product
3. Age range of people interested
4. Expected number of headphones to connect to the device simultaneously
5. Expected price range for the device

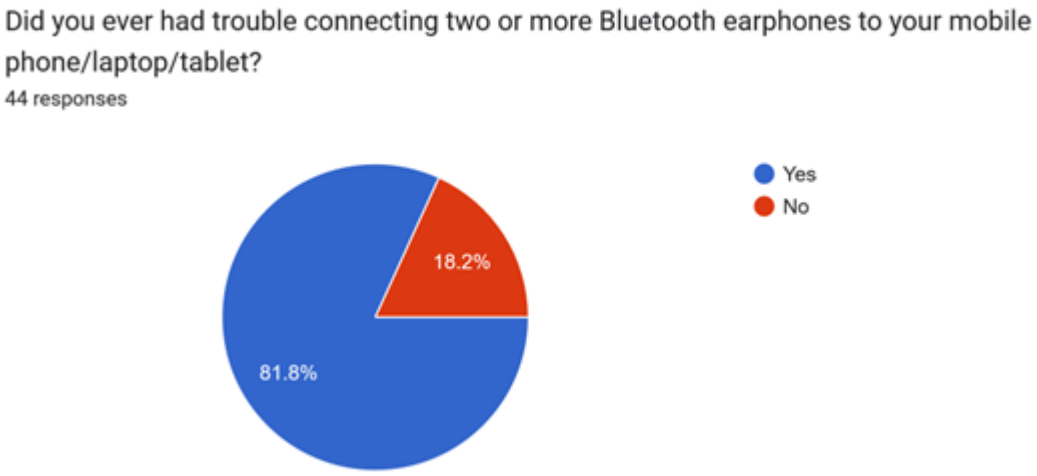


Figure 1: Validation of the Problem

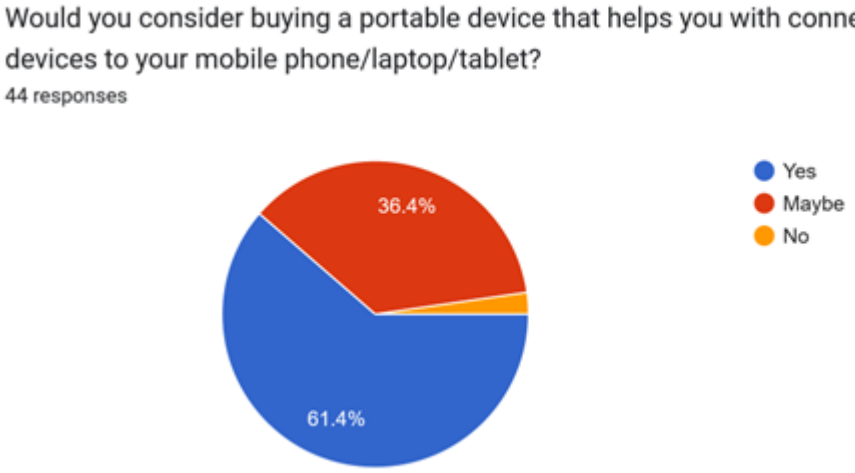


Figure 2: Stakeholder Interest

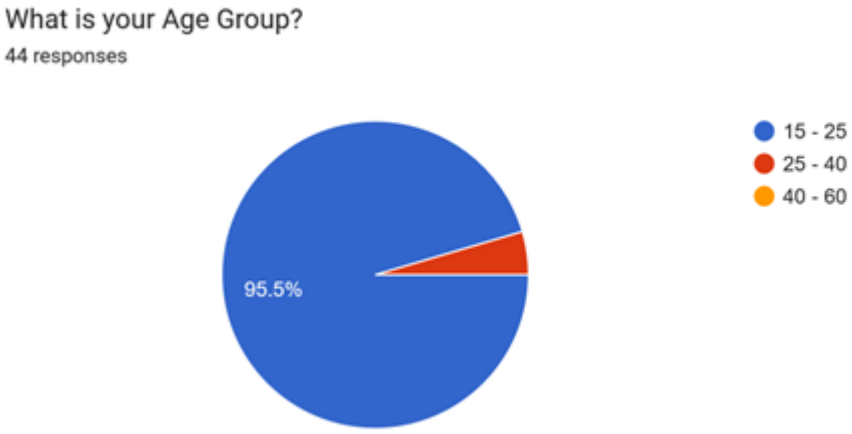


Figure 3: Interested Age Range

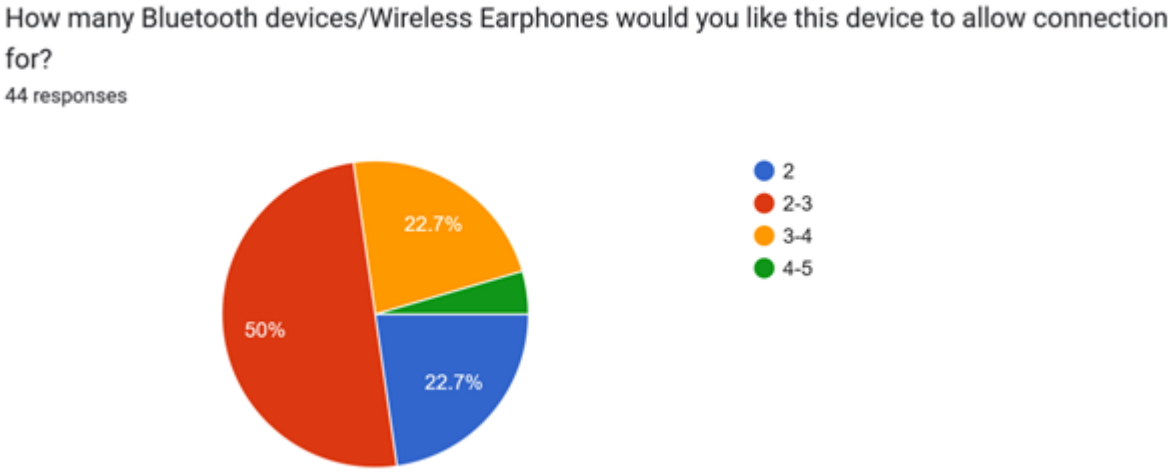


Figure 4: Expected Connections Amount

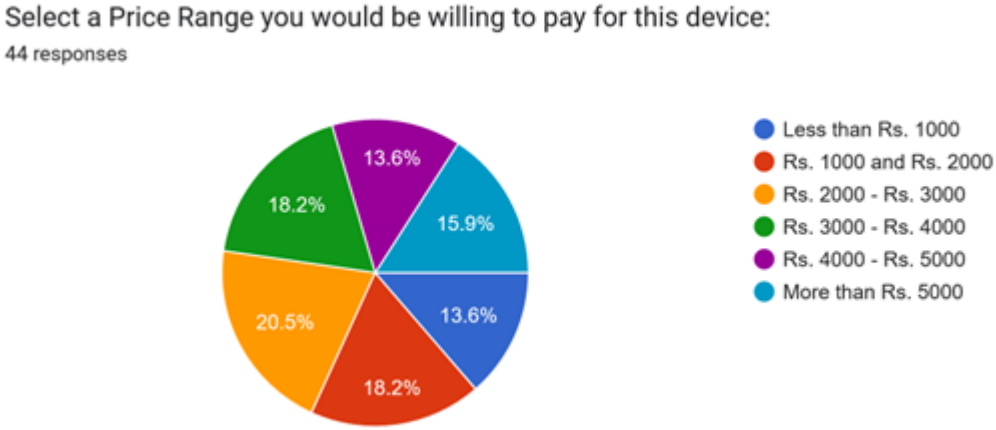


Figure 5: Expected Price Range

From this evaluation, it was determined that our primary shareholders were in the young adult demographic. The requested range of devices to be connected simultaneously was between 3 and 4. Regarding the expected price range, the responses received were inconclusive; resulting in a large variety of expected prices for our product. We attribute this to both the novelty of the device being proposed and the lack of an alternative product as a point of reference for price estimation. This further demonstrates the potential market for this device.

8 Final Budget

Component Name	Unit Price (Rs.)	Quantity	Total Price (Rs.)
KCX-BT-EMITTER	500	5	2500
NE5532 Operational Amplifier	45	5	225
Miscellaneous Components			1600
Enclosure 3D Printing			5000
PCB Printing	2100	1	2100
Total			11425

We have decided to sell the device at a price of Rs.10,000 after considering two major factors:

- The cost for the device components are relatively low, only totaling Rs.6425 (a cost lowered when purchased in bulk). The larger expense is accrued in the 3D printing of the enclosure - an issue we aim to avoid by using techniques like injection molding (given that 3D printing is not viable for mass production). This will in essence bring the production cost down to an estimated Rs.6500.
- The cost range for Bluetooth headphones in Sri Lanka typically ranges between Rs.5000 and Rs.20000+. The cost of Bluetooth speakers in Sri Lanka ranges between Rs.10000 and above. Given our device's similar nature (Bluetooth audio sharing), we believe that the price decided upon will be appropriately received by the market.

9 Marketing and Sales

Our primary focus is to position the device as the essential audio-sharing solution for institutions such as offices, libraries, and universities. In environments like study rooms, meeting rooms, or shared workspaces, our device — conveniently installed on tables — allows users to effortlessly connect their phone or laptop and share audio with multiple Bluetooth earbuds. This enables seamless group participation in virtual meetings, lectures, or collaborative work sessions without external noise.

We are also targeting groups of travelers — friends, families, or couples — who want to enjoy music or watch movies together. Whether on a road trip or relaxing at a destination, our device makes audio sharing effortless and wireless. Additionally, when installed in cars or family vans, it allows passengers to enjoy entertainment privately through earbuds, without distracting the driver.

For the initial phase of manufacturing, we plan to produce 200 units of the audio sharing device. PCB fabrication will be outsourced to a trusted partner, as we currently lack the in-house capabilities and specialized equipment required for precise and reliable PCB production. In contrast, the device enclosure will be manufactured in-house using high-quality injection molding. This approach not only allows us greater control over product quality and aesthetics but also helps safeguard our unique industrial design from potential duplication — a common risk associated with outsourcing enclosure production.

10 Task Allocation

Name	**Task**
Imaduwage O.N.H.	Circuit Design, PCB Design
Ilankoon I.M.M.K.B.	Circuit Analysis, Soldering
Rathnayake M.A.G.K.N.	Enclosure Design, 3D Printing
Dilhan W.A.	Product Design, Assembly