MISTER MIXER
Group 14
Divide & Conquer

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Chapter 1

Executive Summary

As students who are also in bands, we are constantly searching for ways to make the set-up process more streamlined, whether this be through buying more gear or learning new workflows. However, at the end of the day, we may run into problems with pricing and modularity. Normally, an entire rig of equipment will set the musicians back multiple thousands of dollars, all while taking up large amounts of space and creating a mess of cabling. To solve these practical limitations, we envisioned a senior design project with the following goal - to create a low-cost and high performance audio mixer. Additionally, with the major boom in the usage of artificial intelligence, we were inspired to implement some novel AI features to streamline the workflow of audio mixing.

While audio mixers are ubiquitous, the most common (and subsequently lowest cost) are of the analog variety, which is a tried-and-true technology that lacks any option for configuration as well as being generally bulky. From experience, it is also relatively common to have errors with the mixing console during live settings, too, which is not ideal and introduces more problems into the loop. While analog mixers have some filters (low, mid, high) and effects (reverb, delay), anything more than that is only seen in the higher echelon professional gear. If a traveling musician needs to use their analog mixer to monitor and mix themselves, they would also need to travel with a bulky rack of pedals to achieve the various audio effects they desire on their instruments. This brings us to digital mixers, which while having more configurability, cost a fortune for even the lowest level of gear. This is not to mention that these digital mixers usually do not have touchscreen functionality and rather rely on faders entirely, as well as being run by low-powered computers. The mixers are able to work due to the use of highly specialized DSP chips, which are both difficult to interface with and configure.

With this, we seek to combine the present powers of a low-cost general computer to create an all-in-solution for audio mixing that includes AI auto-mixing features, similar to those seen in Izotope Neutron 4. This device would allow for high-level mixing capabilities at the fraction of a price while also combining hitherto separate technologies. Utilizing many off the shelf components, we are attempting to create an approachable and modifiable device that will be able to be more robust and feature-rich than any standard analog or digital mixer. The computer itself will be programmed using a real-time operating system to maximize data processing speed and a custom interface will be designed to ensure a smooth experience for the end user.

To conclude, we seek to create a project that advances the world of low-cost audio mixing while including capabilities not yet on present devices through emulation of state-of-the-art techniques currently used in the audio engineering field. Through this project we will have a deeper understanding of the fundamentals of audio engineering along with the creation of a usable and effective product for our future selves. By combining general computing audio technologies with mixers, the [AUDIO MIXING TEAM] aims to allow ourselves and other musicians to be able to produce a powerful device at a fraction of what present consumer devices cost.

Chapter 2

Project Description

2.1 Motivation and Background

As mentioned in the executive summary, music is an expensive and somewhat cumbersome hobby to partake in; there is a lot of equipment required. This extends to all facets of playing and performing. Many beginner bands have no feasible way to mix their audio, which ultimately leads to subpar, unmixed performances that affect audience enjoyment or even playing ability. Even if they possess some sort of cheap, analog mixer, they face limitations with creative effects, parameter recall, workflow intuitiveness, and bulkiness (especially if they need a pedalboard setup on top of the mixer).

These limitations were experienced by the authors themselves. As former members of a band, they would perform in miniature concerts on top of UCF garages. When multiple bands would perform, substantial intermissions would take place between performances due to the reconfiguration of instrument connections and the analog mixer board. While some overhead was unavoidable, a lot of it could have been negated with mixer presets, instant recall, and a streamlined mixing workflow. This led the authors to realize that there is a niche in the market for an all-in-one mixing solution for fledgling bands and performers.

2.2 Goals and Objectives

We desire to make a digital mixer that has a compact form factor, an abundance of creative effects, and an intuitive workflow that augments the creative vision of any group of performers. This will provide for an all-in-one gigging solution for small bands. The goals needed to realize this vision are outlined below.

Basic Goals:

- Basic audio mixer capabilities (Analog I/O, summing)

- Library of creative audio effects that can be applied to inputs
- Intuitive touchscreen interface to easily control effects and routing
- Wireless control through mobile app
- Auto-mix feature to speed up workflow

Stretch Goals:

- USB support for external control devices (foot switches, MIDI controllers) to enable easier control and interaction with the system by performers
- Bluetooth input/output for backing tracks
- Ability to connect to a computer via USB for easy recording and data transfer

The specific technical objectives below outline the implementation details required to achieve the desired functionality, with a focus on both essential features and additional enhancements.

Objectives:

- 8 analog inputs channels w/ ADC
- Line out, headphone out
- Volume Control
- Panning
- Summing
- Power supply
- Digital touchscreen interface
- DSP effects
  - Reverb
  - Delay
  - Compression
  - Equalization
  - Chorusing/Flanging/Phaser
- Auto-mix algorithm
  - Automatic volume balancing
  - Automatic effects application based on performance genre and instrument
  - Automatic equalization to unmask instruments

2.3 Existing Product/Past Project/Prior Related Work

The closest existing product to our proposed device is the Behringer Flow 8. It features 8 analog inputs including XLR and line inputs, as well as a Bluetooth streaming input. It also features wireless control over Bluetooth with a mobile app in addition to the analog controls. The mixer has the capability to apply several musical effects on send channels [1]. The main strength of this digital mixer is the low price for the amount of functionality provided – namely, the Bluetooth capabilities and competent control scheme. Even so, there is not much more to the device in terms of workflow features and creative effects. It lacks digital parameter recall. This is partly a design choice made due to physical limitation; it lacks expensive, digitally controlled flying faders and instead opts for analog faders which do not offer any digital state control. Additionally, the library of DSP effects is not very comprehensive. There is still a clear need for creative effects and pedalboards to be applied before any instrument enters the mixer. These limitations have spurred us to create something more useful for the small performing band. In comparison, our mixer would have digital recall, many more creative effects, and an auto-mix feature

Figure 2.1: Behringer Flow 8 - Compact 8-Channel Mixer. **MSRP $299.99**

Another product similar to our proposed device is the Mackie MobileMix 8-channel mixer. It is generally geared towards smaller performances in outdoor or other mobile settings, similar to our project. This miniature mixer features 8 channels of varied analog input (with 2 microphone preamps), Bluetooth input, monitoring outputs, and a small selection of effects (2-band EQ, reverb on a send channel). The control scheme is fully analog; the board is entirely controlled with potentiometers and buttons [2]. Like the previous example, this mixer once again has a very enticing cost to performance ratio, but the capabilities are little more than that of a typical analog mixer. The Bluetooth capability is once again a very nice feature to have, but for over $200, we believe a mixer is capable of much more functionality. In comparison, our mixer would have digital recall, more creative effects, and the auto-mix features. Other mixers similar to the MobileMix also have very few effects other than panning and EQ functionality.

Figure 2.2: Mackie MobileMix - Compact 8-Channel Mixer. **MSRP $229.99**

This project attempts to augment this type of pre-existing product and bring it more in line with a higher-end mixer, all the while being similarly priced ($230 for the Mackie mixer as reference price). The features that will remain in common include volume balancing/control, panning, analog and bluetooth inputs, and portable form factor. The areas that would be expanded on will be explained in the paragraph below. Here are several commercially available digital mixers that offer a comparable feature set to what we would like to propose. They are the Allen & Heath CQ-18T and the QSC Touchmix 8. They are displayed in the figures below, 2.3 and 2.4 [3] [4].

Figure 2.3: Allen & Heath CQ-18T - Compact 16-Channel Digital Mixer with Wi-Fi. **MSRP $1,199.99**

Figure 2.4: QSC Touchmix-8 - 14-Channel Digital Mixer. **MSRP $1,149.99**

Several standout features of these mixers include frequency monitoring, wireless control with a tablet app, digital parameter recall, multiple auxiliary mixes, rudimentary automix tools (”Anti-Feedback Wizard”, ”Gain Assistant”), and parametric equalizers. These mixers are very feature-rich compared to both the Mackie and Behringer mixers in computational power, workflow features, signal routing, and effects, but this comes with a significant cost increase, almost $1000 over the others. Additionally, they are less portable (particularly the Allen & Heath CQ-18T). Ideally, our mixer would be comparable to these digital mixers with the same price point and form factor as the Mackie mixer, all with the addition of the new auto-mixing features as well as a control scheme that mimics those of Digital Audio Workstations. This would create an option in the market for a mixer that is affordable, yet extremely capable with a novel workflow that allows for greater creativity than with the typical analog mixer.

We will concede that several features found in high-end digital mixers must be omitted or pared back due to practical constraints. One of these is physical controls. Due to design time and cost constraints, almost all controls on our mixer will be through the touchscreen. There may be one rotary encoder, but we will lack the plethora of physical buttons and knobs that these competing mixers have. One other feature that would not be present is the capability to configure multiple different auxiliary and monitor mixes. We only have one line-out and headphone out, so this would not be possible to implement. Furthermore, even if we did decide to upgrade the amount of hardware outputs, we believe that would not significantly benefit the performances of small bands who do not have multiple PA systems and monitoring setups. This would simply incur extra cost with little to no benefit.

2.4 Key Engineering Specifications

Table 2.1 outlines the specifications targeted for this project. These specifications were established to ensure our digital mixer remains feature-rich compared to the consumer market options while also considering the time and money constraints of the project.

Attribute	Description
Size	(12” x 8” x 2”)
Weight	$<$10 lbs
SNR (Signal to Noise Ratio)	**70 dB**
Inputs	8 TRS, 4 XLR (w/ combo jack), 1 USB, Bluetooth
Outputs	1 Stereo Out, 1 Headphone-out, 1 USB
Preamp Gain	$>$50 dB
Digital Effects	**Gain, Panning, Delay, Compression, Equalization, Chorus/Flanger, Distortion, Amp Simulator**
Maximum Power Usage	50W
Auto-Mixing	Automatically set levels, EQ, creative effects
Cost	$<$\$400
Latency	**$<$20ms**

Table 2.1: Table of Proposed Design Specifications

2.5 Hardware Block Diagram

Included below in Figure 2.5 is our proposed hardware diagram. The blocks are colored to indicate the main person responsible and the color key is included on the diagram. The overall topology of our system is a dual-processor setup with one MCU to handle DSP for streams of audio and a Raspberry Pi 5 SBC to handle state management, wireless communications, and the AI auto-mix model.

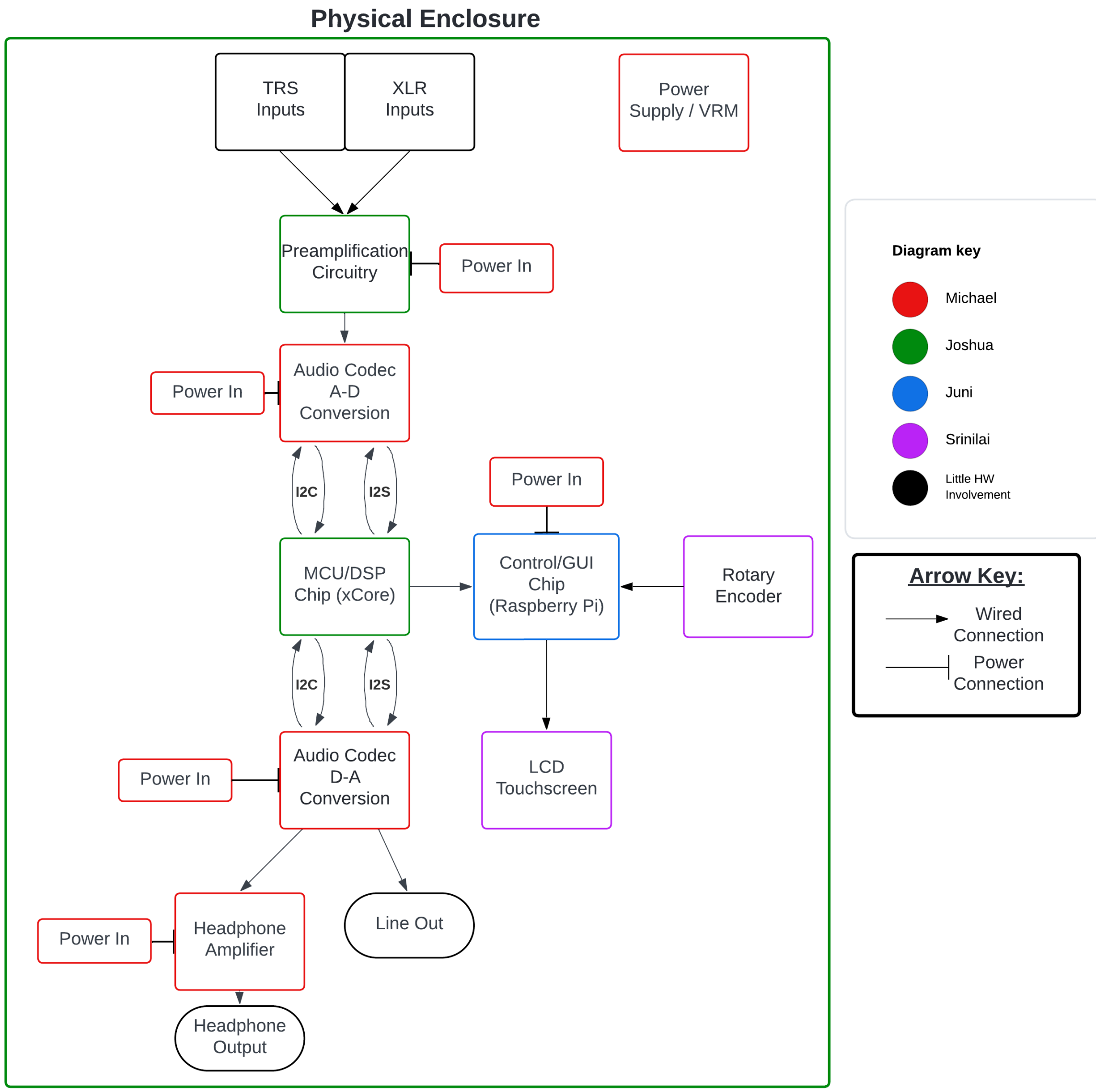

Figure 2.5: Proposed High-level Hardware Block Diagram

2.6 Software Architecture Diagram

The most important requirement is reliability during live performance – ensuring no drop-outs in the audio stream, as well as minimizing latency and jitter as much as possible [5]. The design of our software architecture reflects this. The primary audio processing function, consisting of the most real-time sensitive mixing of the signals from the eight input instrument jacks, will be essentially sandboxed from the remainder of the software, only connected via a lock-free command channel. In this way, it can be ensured that this processing is performed in an entirely deterministic fashion, allowing us to make guarantees regarding reliability for live usage.

The highest level description of our architecture is that it consists of two modules: the Control Module, and the Processing Module. These modules have a leader-follower relationship to each other; the Control Module manages the disparate sources of commands issued by the user, combines them into a single, coherent state, and then applies this state to the Processing Module. The Processing Module autonomously processes signals, consuming and producing raw digital audio and interfacing directly with hardware.

In contrast to the tight processing deadlines imposed by the need for real-time performance for live performance, less real-time sensitive audio processing can be performed by the Control Module. This is done independently of the Processing Module by extracting input audio before it enters the Processing Module, and injecting output audio after. In this way, we enable functionality such as visual monitoring of input signals on user interfaces, and allowing for the streaming of audio over Bluetooth.

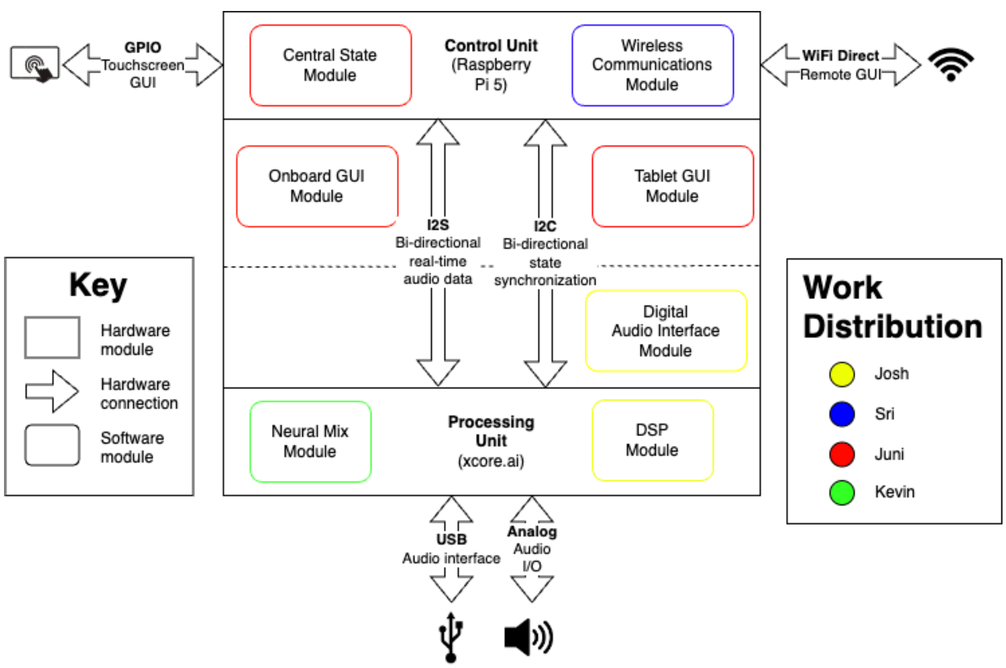

Figure 2.6: Proposed Software Architecture Block Diagram

2.7 House of Quality

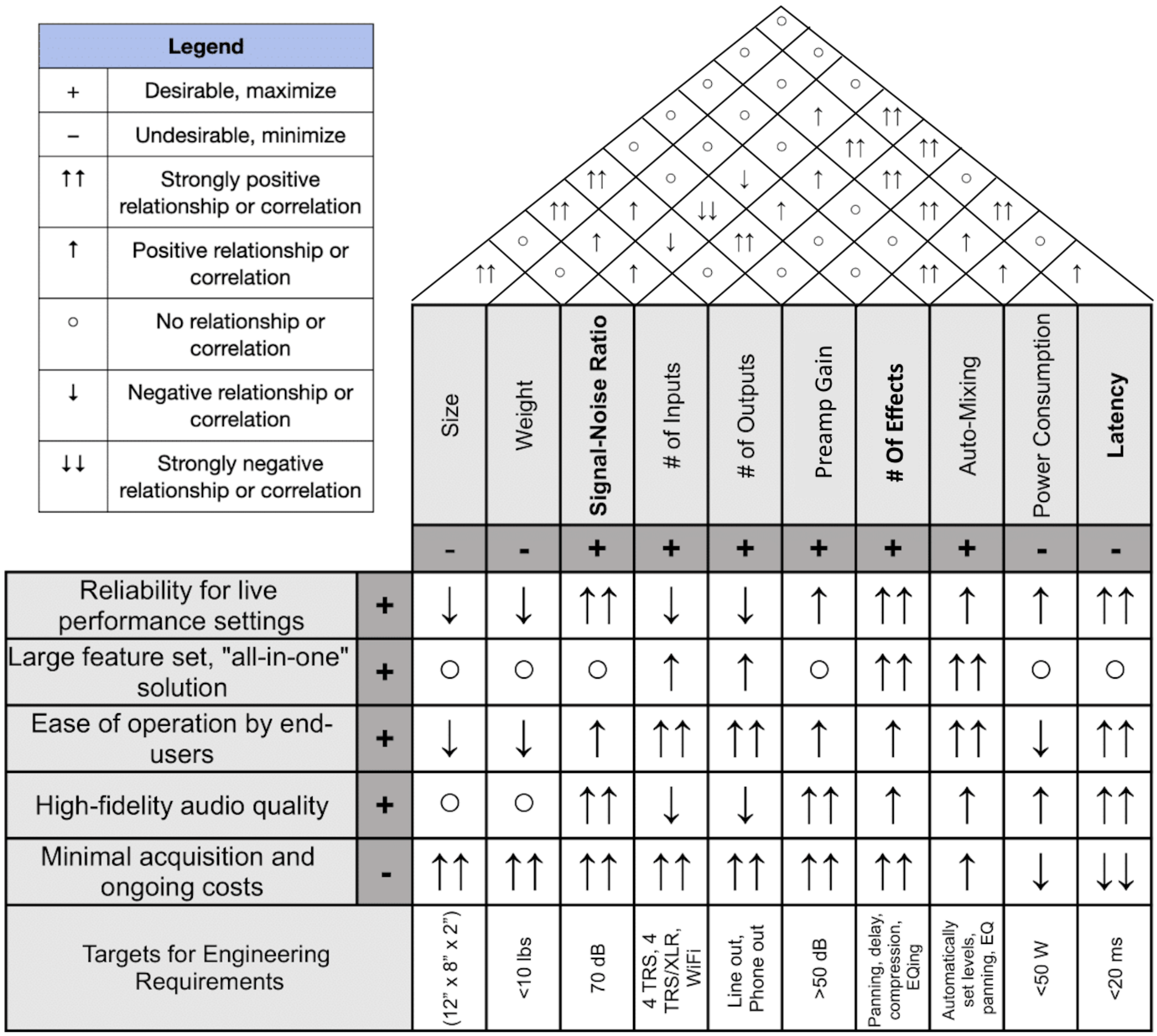

Figure 2.7: House of Quality Diagram

Chapter 3

Standards and Design Constraints

3.1 Relevant Standards

Discuss relevant standards in detail.

3.2 Design Constraints

Discuss design constraints in detail.

Constraint	**Description**
Cost	The ideal maximum budget for this project would be under $400, though $500 may be required. Since we are self-funded, there is no definitive maximum.
Time	The current semester of SD1 gives us roughly 3 months (or 12 weeks) of time to properly plan and develop the software and hardware prototype for this device. Once in SD2, we will have another 3 months to finalize our project before the final deadline. Using our time wisely during SD1 is the most crucial part for the success of the project.
Product Availability	The major concern we have over product availability is that of individual parts, though this can be adjusted by finding a suitable replacement as none of the required parts are novel to the device.
Social	There are no social constraints from the project itself.

Table 3.1: Identified Constraints

3.2.1 Economic & Time

Due to being a self-funded project in addition to purposely being low-cost, significant thought went into the selection of the components used. The major economic constraints placed upon the project will impose compromises between the quality of parts and the overall product.

3.3 SD1 Documentation timeline

Task	Start Week	Est. Duration (Weeks)
Brainstorming/Preliminary Research	Start of Summer	12
Individual Research	8/19/2024	1
Finalize project scope	8/23/2024	1
Divide and Conquer	8/26/2024	2
30 page milestone	8/19/2024	3
60 page milestone	9/9/2024	3
90 page milestone	9/30/2024	3
120 page milestone	10/21/2024	3
Final draft milestone	11/11/2024	3
Review	11/21/2024	0.5

Table 3.2: Project Documentation Milestone

3.4 SD2 Design Timeline

Task	Description	Start Week	Est. Duration (Weeks)
Interfaces between work units	Establish contracts between individual modules	1/6/2025	1
Power supply	Test proper power delivery to hardware components	1/13/2025	2
Mixer state protocol	A standardized protocol for inter-module state communication is drafted	1/20/2025	1
Audio work loop	Audio successfully passes through XCore unit	1/27/2025	3
Basic onboard GUI	Minimal GUI implemented for testing purposes	2/3/2025	2
Communications co-processing	Developed successful communication schematic for WiFi and Bluetooth capabilities	2/24/2025	3
Machine learning model	Successfully predicts optimal mixing parameters for audio inputs to enable real-time audio mixing	2/10/2025	4
Control & DSP integrated	Raspberry Pi can send control signals to xCore	3/3/2025	3
Compute Integration	xCore and Raspberry Pi properly communicate with each other through appropriate protocols.	3/31/2025	4

Table 3.3: Project Design Milestone

Chapter 4

Administrative Content

4.1 Budget Estimates

The budget estimate for our project is shown in Table 4.1 below.

Item	Quantity	Price Per Unit	Adjusted Price
Raspberry Pi 5	1	$80	$80
Raspberry Pi Touchscreen	1	$60	$60
Raspberry Pi Display Cable	1	$1	$1
TRS Jack	6	$2	$12
TAA5242 ADC	8	$3	$24
TAD5242 DAC	1	$4	$4
TPA6111A2DR Headphone Amplifier	1	$1	$1
USB-C Adapter (For MIDI input)	1	$6	$6
Power PCB Estimated costs	1	$50	$50
Metal Casing	1	$20	$20
XU316-1024-QF60B-C32 (DSP Chip)	1	$8	$8
XLR Panel Mount Connector	6	$3.50	$21
Estimated Total:			**$288**

Table 4.1: Estimated Cost of Production

4.2 Work Distributions

Task	Primary Person	Secondary Person
Power Circuitry Design	Michael Meyers	Joshua Yu
Housing & Enclosure Design	Joshua Yu	Michael Meyers
MCU Integration	Joshua Yu	Michael Meyers
DSP Effects	Joshua Yu	Juni Yeom
AI Programming	Kevin Kurian	Srinilai Kankipati
Mobile App/GUI	Juni Yeom	Srinilai Kankipati
LCD Screen/Embedded GUI	Srinilai Kankipati	Juni Yeom
Wireless Communications	Srinilai Kankipati	Juni Yeom

Table 4.2: Duty Distribution

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[1] Behringer, "Behringer flow 8 8-channel digital mixer," *https://www.gear4music.com/us/en/PA-DJ-and-Lighting/Behringer-FLOW-8-8-Channel-Digital-Mixer/3N67*, 2024.

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[5] R. Bencina, "Real-time audio programming 101: time waits for nothing," *www.rossbencina.com. http://www.rossbencina.com/code/real-time-audio-programming-101-time-waits-for-nothing*, 2011.