ECE 445
Project Proposal
Fall 2019

Hip Hop Xpress: Double Dutch BoomBus Window Equalizer

Team 46
Anushrav Vatsa (avatsa2), Colin Sandstrom (colinls2), Ioan Draganov (idraga3)
Professor: Rakesh Kumar
TA: Jonathan Hoff (jehoff2)

13 February, 2020 (Thu)

Contents

1. Introduction

1.1 Objective

Dr. William Patterson has been bringing the art and cultural experience of music to communities around the country with his Hip Hop Xpress project. The newest version of this project is the Double Dutch Boom Bus, which will be a repurposed school bus outfitted with all the equipment necessary to bring hip hop wherever it's needed. From the Hip Hop Xpress site, "[The Boom Bus] will be an internet-connected mobile classroom and sound studio, a means to collect oral histories, a cross-generational catalyst for music sharing and production, and a method to link communities across the state through music, dance, visual arts, and history"[1]. Dr. Patterson has reached out to us in the ECE department for assistance designing equipment to enhance the bus's interactivity and function.

We want to enhance the Boom Bus experience by integrating the windows as a part of the music-making process. We'll connect sensors to the windows that detect how far the windows have been moved, and use this data to control an audio mixer running on a microprocessor. The windows will serve a function similar to that of a slider on a mixing board, providing a visual of how effects are applied to an audio signal to the crowd outside of the bus. They can also provide an interactive experience to those on the bus, allowing them to work together with audio mixing, a process normally done individually. This project will try to address the most important aspect of Dr. Patterson's presentation, which is to pull more people, especially the younger generation, into the music experience. We believe the best way to do that is to let the audience be a part of the musical experience themselves.

1.2 Background

When the Hip Hop Xpress program was started in 2010, "The purpose of the Xpress was to support efforts to build and rebuild community in spaces where civic and social groups such as neighborhood associations were hosting community-building activities"[2], but the first iteration was retired after only six months of operation, and it was replaced by the second iteration from 2012 to 2018, but even then the Hip Hop Xpress ended up too costly to repair and maintain. One of the main issues with the first two iterations was that they had too many moving parts. They were originally trailers that would be loaded with music-making equipment and sound systems, then hooked up to a truck and driven around. Set-up and clean-up processes were time-consuming, and the trailers and equipment required separate storage spaces and maintenance. The newest iteration that we are working on now, the "Double Dutch Boom Bus" seeks to resolve those issues by employing a more streamlined design that integrates the equipment with the bus, and serves as more than just a delivery system. The Boom Bus aims to be a unique and inclusive environment that brings people together through music. We aim to augment this environment by making the bus itself part of the experience, similar to an interactive museum exhibit. One of the main focuses of the bus is to disconnect the learning process from a conventional classroom, which many kids don't respond well to. The Boom Bus will allow for learning about hip hop and making music through a more relaxed, social experience, giving kids an opportunity to learn by relaxing and having fun.

1.3 High-Level Requirements

- The system must be able to convert the levels of the windows into digital values to control our audio system
- The system must integrate with the onboard audio system of the Boom Bus
    - The system will sit between the mixer and the amplifier and will take the same input (TRS or RCA) as the amplifier and output the appropriate signal to the amplifier after equalization
- The system must have real-time communication and processing systems to prevent any delays and async behavior since we are working with a music system.

2. Design

2.1 Physical Design and Block Diagram

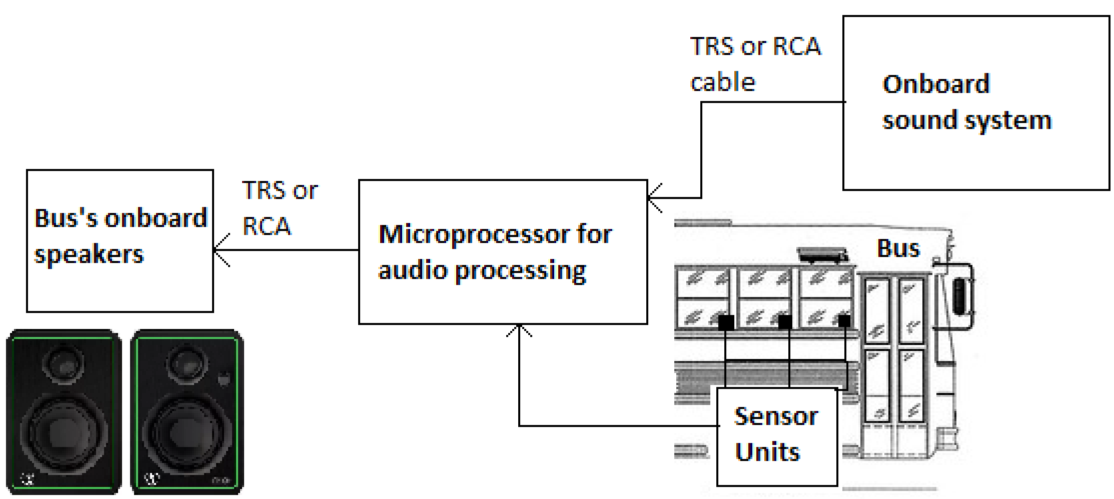

Figure 1. Physical design diagram

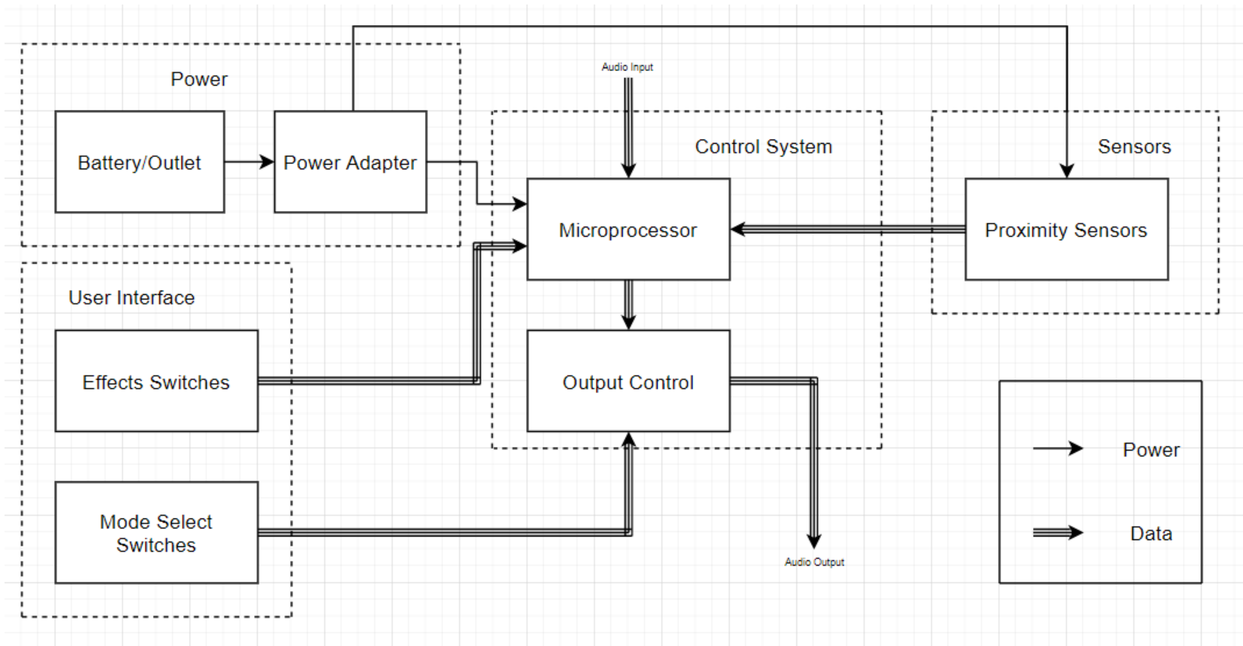

Figure 2. Block Diagram

2.2 Functional Overview

Our design needs to allow for the following in order for this project to be successful:

- Easy and interactive user interface
    - We want to create a system that will make the technology in our design invisible to the user and create a more inviting environment. The goal here is to make sure all the sensing equipment is hidden from the user and cannot be interfered with.
- Active real-time digital filtering
    - To achieve real-time filtering we want to use a low powered microprocessor and get the desired bit precision.
- Low noise design
    - One of the primary goals of this project is to achieve a good musical experience for our users which means we need to make sure our system is not introducing unnecessary noise in the system that can affect the quality of the music. To ensure this we will be designing our system to match the sample rate and bit precision of the native music system on the bus to ensure no noise introduction from resampling or bit-precision error. Furthermore we will be doing the entire filtering digitally and keep the analog segment of our system limited to ensure no noise is introduced from that.

2.3 Subsystems

2.3.1 Control System

We intend to utilize the MSP430F552x**[3]** range of microprocessors from Texas Instruments. They give us the ideal bandwidth, sensor input ports and the processing power to achieve filtering that can be considered real-time (under 5μs delay) while needing very little power to run.

Requirement: Control system must be able to apply a digital filter controlled by sensors to the audio without delaying more than 5 μs.

2.3.2 Sensors

This subsystem will sense how high the windows are and provide this data to the control subsystem. Optical sensors will be mounted at the bottom of the window to be able to tell when the windows are open or closed.

Requirement: Sensors must be able to detect window height within 1cm of accuracy.

2.3.3 User Interface

Our primary control unit will give the user some essential control over the system. This includes:

- *Basic power switch*
- *Routing Control Switch* to route the sound directly to the amplifier and bypass our system
- *Effects Control* to allow for master volume control and other audio effects we can emulate on the MCU

Requirement: Switches must shut off the other subsystems and route the audio straight to the output past the microprocessor when inactive.

2.3.4 Power

We will use a 12V power adapter to reduce the voltage driving the microprocessor to ~3V, and to power the sensors mounted on the windows as well.

Requirement: System must be able to provide 3V and appropriate current for each separate block.

3. Ethics and Safety

Our device will use voltages and currents that are small enough to not cause harm to humans, and we will have all of our wiring and hardware enclosed in plastic housing to ensure the safety of both humans and our circuitry. All components will not be visible to the end user, so the risk of electric shock is averted. Two ethical concerns arise based on the fact that we are adding these components to the windows of a bus: the emergency exits and inclement weather conditions.

To address the concerns regarding the emergency exits, we will not install any components on the windows that are designated as emergency exits so that passengers are not impaired in their ability to escape in the event of an emergency. If we were to mount any equipment that could get in the way of a passenger in an emergency, this would be a clear violation of IEEE Codes 1 and 9, to "hold paramount the safety of the public" and to "avoid injuring others"[4]. We need to avoid a situation where a person is harmed, even indirectly, because our installation got in their way when they needed to escape the bus.

In addition, any sensors and other equipment that we mount outside of the bus will need to be protected from any inclement weather. We believe that IP44 standards are sufficient to protect our devices from any rain or wind that we can expect to encounter while on the road.

4. References

[1] "About". Publish Illinois Edu. https://publish.illinois.edu/hiphopxpress/ (accessed February 13, 2020)

[2] "Variations on the Hip Hop Xpress". Publish Illinois Edu. https://publish.illinois.edu/hiphopxpress/sample-page/ (accessed February 13, 2020)

[3] Texas Instruments. "MSP430F552x, MSP430F551x Mixed-Signal Microcontrollers". SLAS590N datasheet, March 2009 [Revised September 2018].

[4] "IEEE Code of Ethics". IEEE. https://www.ieee.org/about/corporate/governance/p7-8.html (accessed February 13, 2020).