Automatic Drum Tuner

Project Proposal

ECE 445 - Senior Design Project Laboratory

February 13, 2025

Team 70

Joseph Bacino

Max Wojtowicz

Jonathan Fejkiel

TA: Shengyan Liu

Table of Contents

1. Introduction

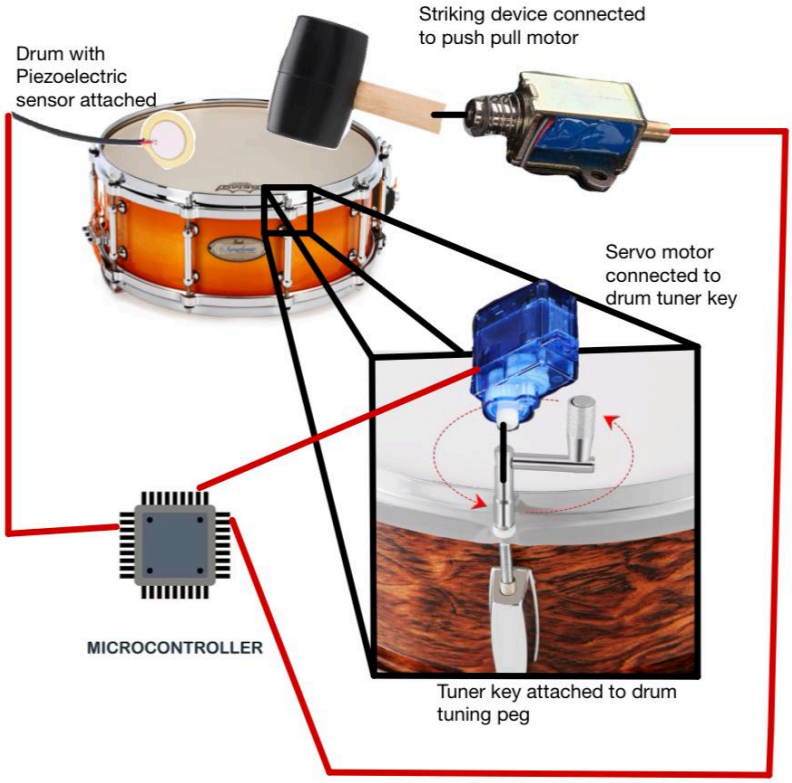
1.1 Problem

Playing instruments is a pastime enjoyed by millions of people across the world. A task that almost every musician must endure before playing is tuning their respective instrument. For many, this is done easily if they are of able body and have good pitch. However, turning lugs and listening for the right tune can be difficult if someone is weaker, such as a child or the elderly, or if they are inexperienced in hearing perfect pitch such as a beginner. Music should be accessible to all people as it is a way humanity has expressed itself for thousands of years. About 66% of Americans have or know how to play an instrument (YouGov). This number shows how important music is to the world, and physical ability should not be a limiting factor in self expression.

1.2 Solution

The solution we propose is an automatic tuner for instruments that will adjust the instrument until the desired pitch is reached. We will specifically design our tuner for use on drums. The device will strike the drum and determine its pitch at the current state. The microcontroller will calculate how much the lugs on the drum should either be loosened or tightened to get closer to the desired pitch. This amount is then translated into motion sent to the servo motor that tunes the drum. The drum will be continuously struck until the correct pitch is found, which only then will the motor stop tuning. If time permits, there will be an application that allows the user to set the desired pitch at their will.

1.3 Visual Aid



1.4 High-Level Requirements List

1. The first requirement for our project is that the mechanism strikes the drum correctly and for the same amount of time and intensity for each cycle as needed. It must be strong enough to create frequency that can be picked up from the piezoelectric sensors and repeated if more tuning is needed. The motor rod should make contact with the drumhead for less than 10 milliseconds to maximize resonance for the drum.

2. The tuning mechanism should be able to apply the correct amount of torque needed to turn the lug to reach the desired pitch/frequency. It should also operate at a constant slow speed of about 5 rotations per minute. We want to avoid any cases of the motor under or over shooting to keep the entire process streamlined and efficient, without unnecessary corrective turns. The motor should be able to produce at most 8-10 in-lbs of torque to reach higher frequencies, but not go over as to not damage the drum hardware.
3. Finally, the pitch detection subsystem should accurately find the pitch of the drum after the hammer has struck. It should only pick up sound from after the hit of the drum and not any softer background audio. To consider the lug to be tuned, we have a tolerance of 5Hz for each pitch. Based on the frequency for notes in the range of the second octave, 5Hz is an adequate tolerance to create a unified sound among all the lugs of the drum.

2. Design

2.1 Block Diagram

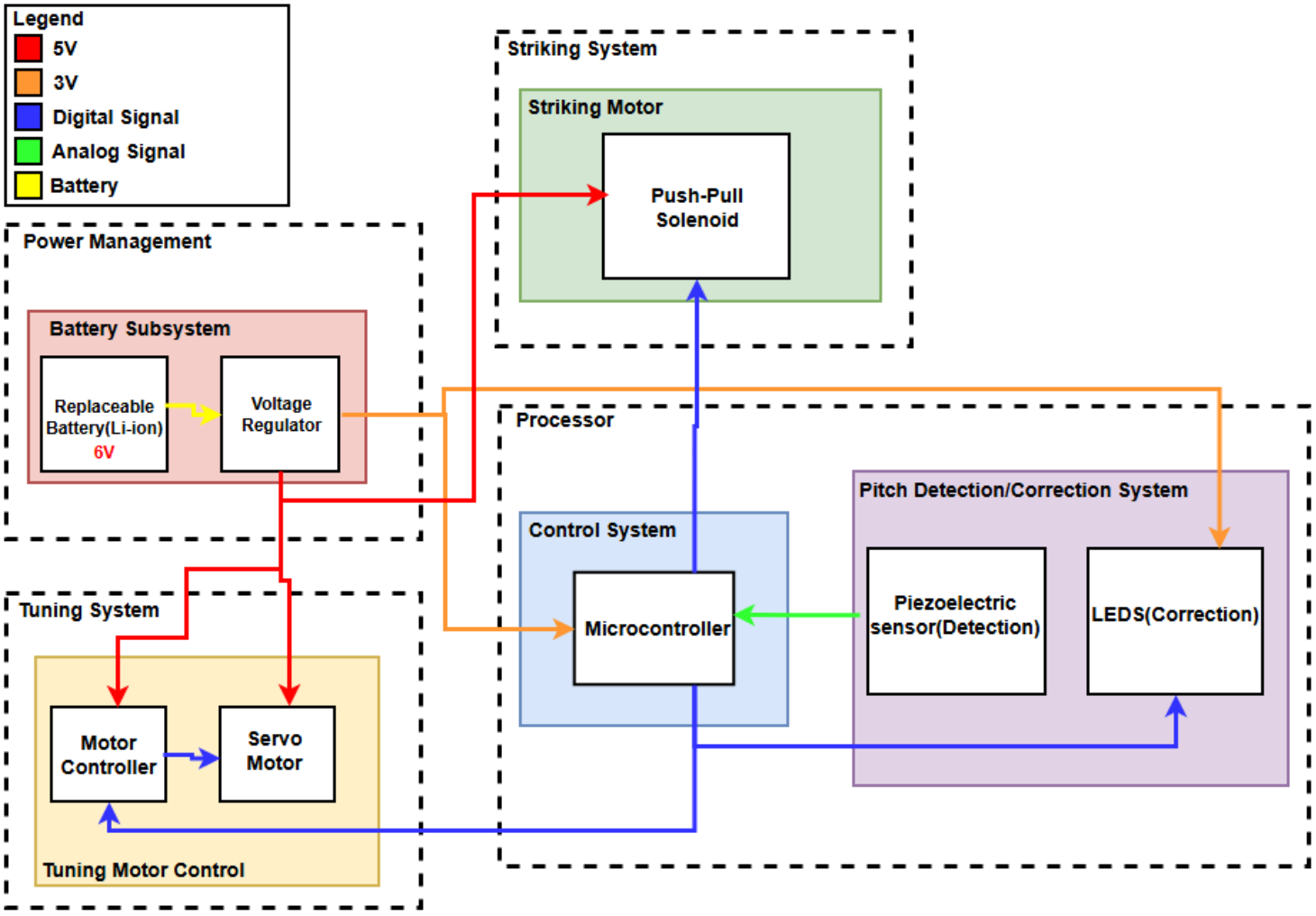


Figure 1: Block Diagram for ‘Automatic Drum Tuner’

2.2 Subsystem Overview

2.2.1 Drum Striking Subsystem

.

1. The first requirement for the striking subsystem is that it can retrieve the signal for a strike to occur from the microcontroller. This is necessary to know when the motor should strike the drum and time it correctly so that it can be picked up from the pitch detection sensors.
2. The next requirement is that the motor always operates when it is instructed to do so by the microcontroller. If it were to fail and not strike the drum when instructed to do so, the pitch detection subsystem would record the wrong sound.
3. Finally, the striker should not remain in contact with the drum for too long. If this occurs, the pitch of the drum will be incorrect and the sound will dissipate faster since the striker will be touching the drum.

2.2.2 Power Management Subsystem:

1. The power subsystem must be able to step-down from 9 V, and be able to continuously supply 5 V +/- 0.1V to our tuning and striking motor systems, while also being able to continuously supply 3.3 V +/- 0.1V to our microcontroller and pitch correction LEDS.

2.2.3 Tuning Subsystem

1. First requirement is for our microcontroller to be able to translate a higher or lower than desired pitch signal into signals that our servo motor controller will be able to recognize. Once this is the case, the motor controller will tell the motor to act accordingly, rotate clockwise or counterclockwise, tighten or loosen. The motor controller will most likely be an H bridge.
2. As the drum is being struck, our tuning subsystem should be able to continuously receive the signals mentioned in point 1 and continuously rotate the lugs in either direction to either tighten or loosen the lugs until the desired pitch is met.

2.2.4 Pitch Detection and Correctness Subsystem

1. Our microcontroller must be able to correctly identify the most prominent frequency/pitch from the piezoelectric sensor readings.
2. Through our microcontroller, the detected pitch must be correctly identified as lower or higher than the desired pitch to be able to send the correct signals to our tuning system, as well as sending the correct signals to our LEDS to signal to the user the progress of the tuning process(Red = too low, Green = within tolerance, Blue = too high).

2.3 Tolerance Analysis

In the design of the ‘Automatic Drum Tuner’, maintaining precise voltage levels is essential for stable, and optimal operation. The microcontroller operates at around 3.3 Volts, and

to ensure proper functionality, we will allow a tolerance of ±0.1V, keeping the voltage between 3.2 and 3.4 Volts. Similarly, the motors require 5 Volts, so we will ensure the motor voltages stay within the 4.9V to 5.1V range. Staying within these limits prevents underpowering, which could cause unreliable performance, and overvoltage conditions, which could lead to overheating or damage. Proper regulation of these voltages is critical for the efficiency of the system.

3. Ethics and Safety

Since our 'Automatic Drum Tuner' is a fairly simple device, it has very few ethical and safety concerns. We will formally adhere to the IEEE code of ethics [2]. We will take into great consideration advice given to us by our TA and professors. All of those working on this project will be respected and be heard accordingly, as also to any other individuals that we work with. Since our project design incorporates a battery, we will ensure compliance with all safety and regulatory standards to prevent fire hazards and potential injuries related to lithium-powered devices. This includes maintaining battery temperatures between 30°F and 100°F. Another major precaution will be avoiding any actions that could damage the battery, which include dropping, crushing, or puncturing the device.

4. References

[1] Journalist, Linley SandersData. "Younger Americans Are Increasingly Exposed to Playing Music and a Wider Range of Instruments." *YouGov*, 23 Aug. 2022, today.yougov.com/society/articles/43512-young-americans-increasingly-exposed-music.

[2] *IEEE - IEEE Code of Ethics*, www.ieee.org/about/corporate/governance/p7-8.html. Accessed 13 Feb. 2025.