ECE 445

Spring 2025

Initial Project Proposal

Automatic Guitar Tuner Project Proposal

Nathan Kim (nrkim2) and Ethan Lin (ethanl7)

2/13/2025

TA: Shenyang Liu

Introduction

Problem Statement

For many guitar players, keeping their guitar in tune can be a hassle. Looking at the tuners currently on the market, the most common type of guitar tuner is a clip-on tuner where the player is required to manually tune each string using the attached tuner as a pitch guide. There also exist automatic guitar tuners but these are limited by either the number of strings that can be tuned at once, the price of the tuner, or the amount of work needed to be done by the player (i.e. the player still has to move the tuner around the pegs or strum the strings).

Solution

Our solution is to develop a portable automatic guitar tuner that attaches to all six tuning pegs of the guitar and can tune each string to the standard 6-string guitar tuning (EADGBE). So, the user will intermittently strum all six strings until an LED flashes which indicates that all strings are correctly tuned - an attached Piezo Disk Transducer will be used to determine the real-time frequencies and vibrations within the guitar. To accomplish this overall task, we will introduce 4 essential subsystems: a power subsystem, motor subsystem, processing subsystem, and a vibration-sensing subsystem.
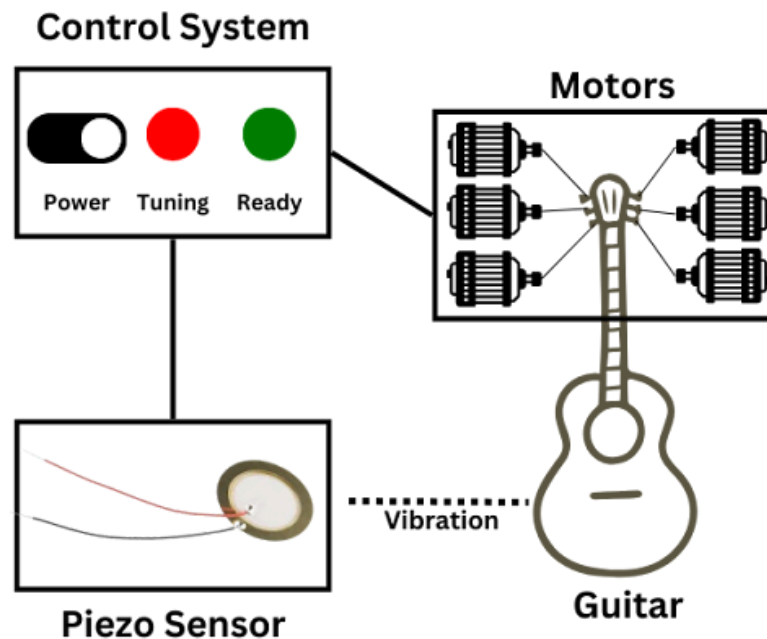
Visual Overview

Figure 1: High-Level Visual Overview of the Automatic Guitar Tuner System

Criterion For Success

- Ability to attach and remove the system within two minutes total
- Ability to tune all six strings within ±12 cents of the set tone per string (the value where people can start to detect when something is out-of-tune)
- Ability to finish tuning all strings within a minute, flashing an LED to visually signify completion
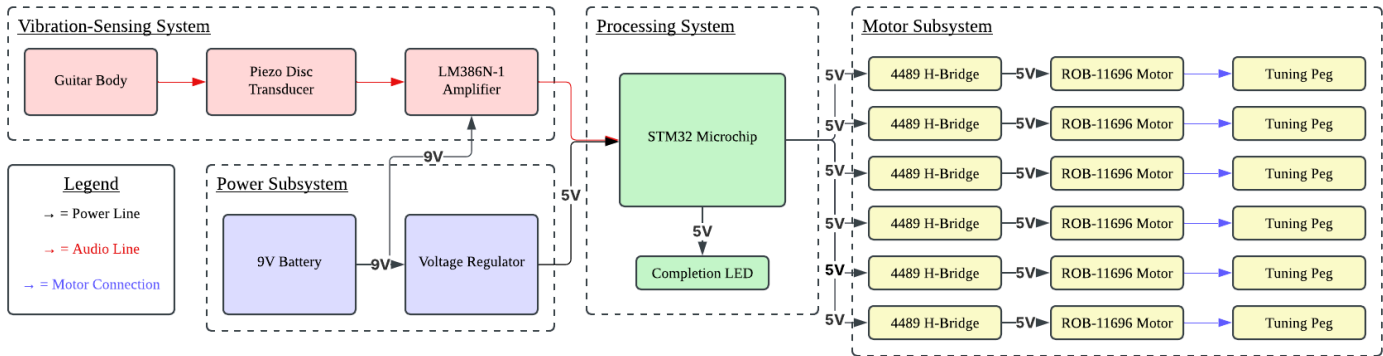
Design

Block Diagram

Figure 2: Block Diagram of the Automatic Guitar Tuner System

Subsystem Overview

Subsystem 1: Power System

The power system will provide power for the motors and processing system. As the design will be portable, it will be run from a 9V battery (233) and require a step down voltage regulator (LM317T) to get the power to an acceptable level for our motor and processing systems. We will also have a battery control system to ensure all our components receive appropriate power.

Subsystem 2: Motor System

The motor system will be responsible for turning the tuning pegs based on the processing system output. There will be 6 motors (ROB-11696), one for each tuning peg, and will be driven by H-bridges (4489) on the PCB. They will also have limited torque and power in order to ensure the system will not damage the guitar.

Subsystem 3: Processing System

The processing system is the heart of the project, as it will take input from the vibration system, distinguish between all six strings, process which direction to tune each string, and finally send power to the motor system to tune the guitar. We will utilize DFT/FFT techniques on the signal from the vibration system in order to identify the six strings' individual frequencies. This will be done by having predetermined ranges for each string and sweeping through that range for the peak. Once the frequencies are separated, we will utilize a tuning algorithm to determine the direction the motors need to tune the guitar.

Subsystem 4: Vibration-Sensing System

This system will take input from a piezo disk transducer (TXJ-055-US) which will read the vibrational frequency from the guitar body and amplify (LM386N-1 Digikey 296-44414-5-ND) it to an acceptable level for the processing system to handle. This system may also take input from multiple transducers placed at multiple locations on the guitar and combine them for a more accurate and reliable input.

Subsystem Requirements

Subsystem 1: Power System
- Must be able to supply a continuous 5V±0.25V for all system components
- Output voltage should not decrease by more than 5% when motors are under load

Subsystem 2: Motor System
- The motor system must be able to adjust pitch within 15 seconds per strum to meet the overall tuning time requirement
- The motor system must rotate tuning pegs with a torque limit of ≤ 0.5 N·m to prevent damage to the guitar

Subsystem 3: Processing System
- Use the STM32 chip to run real time FFTs to analyze the frequency within 50 ms
- The processing system must analyze frequencies with at least ±3 Hz precision in the 80 Hz – 350 Hz range

Subsystem 4: Vibration-Sensing System
- Must be able sense to vibrational frequency of the guitar and accurately output a signal within ±12 cents of the original frequency
- Must be able to amplify the vibrational signal with a gain of 20dB

Tolerance Analysis

The most precise part of the project is to tune the guitar to within ±12 cents of the set tone per string. This accuracy will be determined by two things, the accuracy of the piezo transducer and the accuracy of the motors. The piezo transducer we selected has a resonant frequency around 4.6 kHz. As the typical tuning frequency of a guitar is between 80-350 Hz (from the low E string to high E string), this resonant frequency sits far above the top range, resulting in a flat frequency response from the transducer for our tuning range. Our motors will also be accurate enough to turn the tuning peg to within 12 cents as well.

Ethics and Safety

One potential ethical or safety issue that would arise from this project would be potential harm to people's property (IEEE 2.9). Automatic guitar tuners are not a new idea, but consumers are generally skeptical about them due to their history of damaging the guitars they tune. In order to prevent this, our design limits the power and torque the motors can produce, removing the possibility of damage. Another possible issue would be to respect the work required to produce new ideas (ACM 1.5). Previous ECE 445 groups have created automatic guitar tuners, and our work aims to build on their designs. To prevent issues, we will clearly document our ideation and creation process to clarify our sources and references.