ECE 445

Project Proposal:
Auto-Guitar Tuner
Fall 2025

Team 25
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Introduction

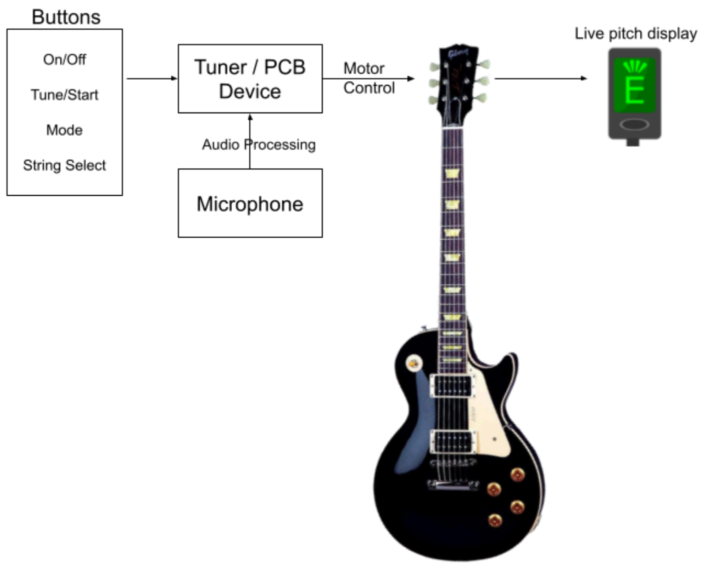
1.1 Problem

When playing guitar, being in tune is essential. When strings are not properly tuned to their correct pitches, the notes played can clash with each other, causing what listeners perceive as being "off" or "out of tune." Accurately tuning a guitar is a challenge for both beginners and experienced players. Traditional tuners require the musician to manually turn tuning pegs while reading pitch information, which can be inconsistent and time-consuming. An automatic solution that can both detect pitch and physically adjust the tuning peg would reduce errors, speed up tuning, and improve usability in practice and performance settings.

1.2 Solution

We propose a handheld automatic guitar tuner integrating pitch detection and motorized peg adjustment into one device. The system will capture string vibrations, process them using a microcontroller to identify the current pitch, and automatically rotate the tuning peg with a small motor until the string is in tune. Since the handheld device tunes one string at a time, it can be used on different guitars without worrying about the various spacing between pegs and strings. A compact LED screen will display the detected pitch and tuning status, while four buttons (Power, String Select, Mode, Start) provide simple user control. The String Select button allows users to cycle through the six guitar strings. Each press moves the selection to the next string in order: low E, A, D, G, B, high E, then back to low E again. This circular navigation lets users easily choose which string to tune without confusion or the need for multiple buttons. The Mode button lets users toggle between preset tuning standards (Standard, Drop D, Open G, etc) to accommodate various playing styles and preferences. The design will run on a rechargeable battery, with all subsystems integrated into a custom PCB for portability and reliability.

Visual Aid:

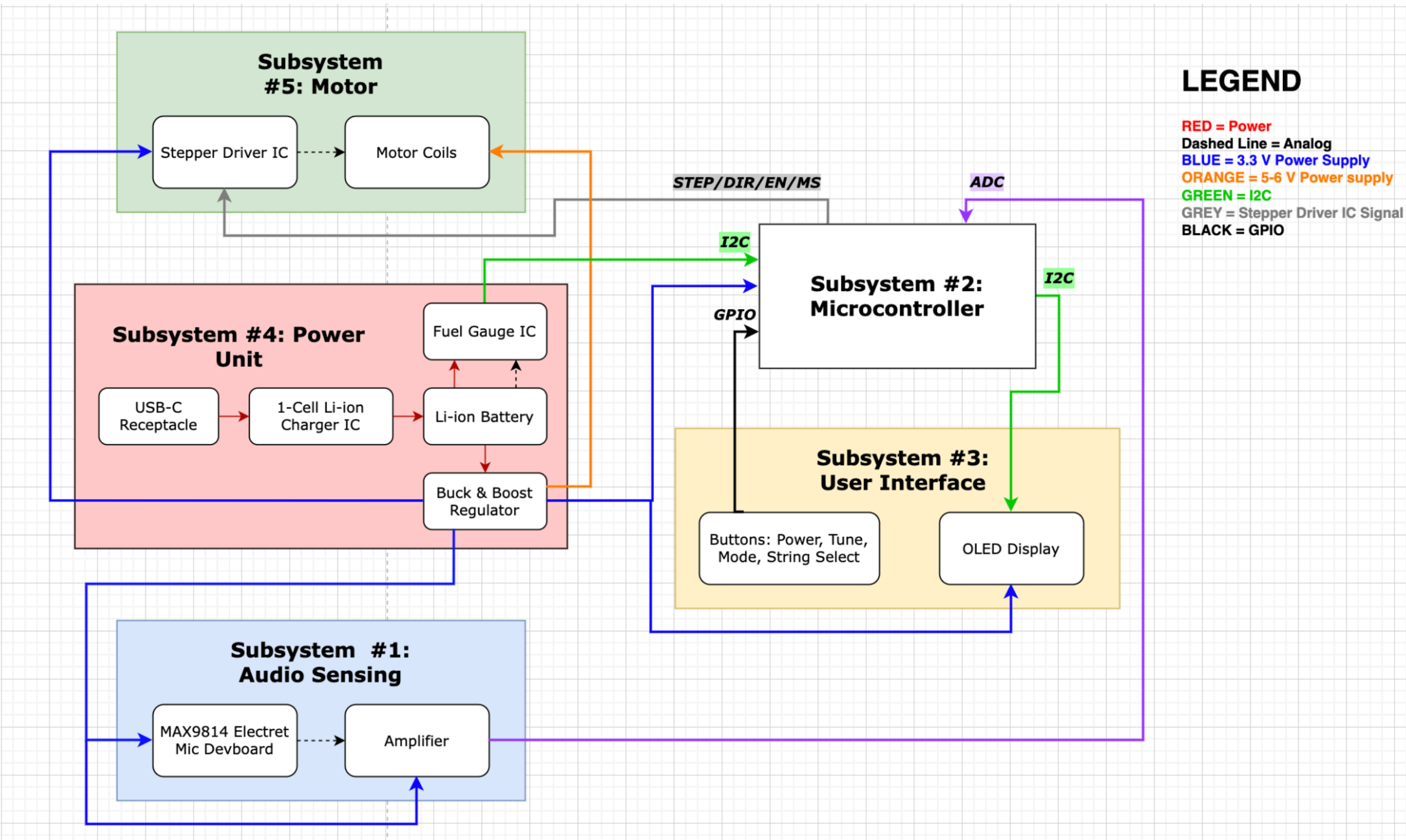


High-Level Requirements:

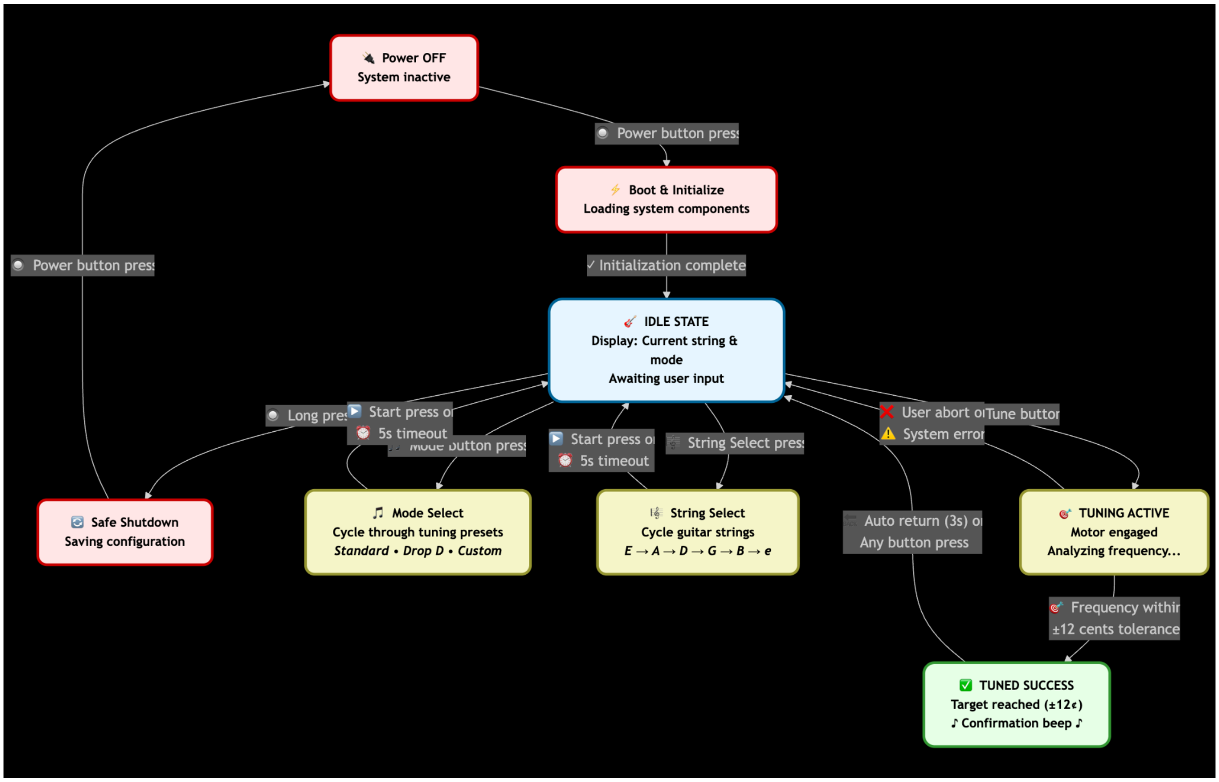
1. *(Performance)* Our guitar tuner should be able to accurately capture each string's pitch, and tune each string in 30 seconds within ±12 cents of the target pitch.
2. *(Compatibility & Safety)* The tuner should function reliably on both acoustic and electric guitars without causing any damage to the instrument or strings.
3. *(Usability and Interface)* The device must provide a **simple control interface** with four buttons (Power, String Select, Mode, Start). The String Select button must allow cycling through all six strings in order, the Mode button must support at least three alternate tunings (Standard, Drop D, Open G), and the LED screen must update the detected pitch and tuning status within **1 second** of plucking a string.

2. Design

2.1 Block Diagram



2.2 Logic Flow Diagram:



2.3 Subsystem Overview

Audio Subsystem: Capture the sound/vibration of the guitar string and convert it to a clean, digitizable signal.

This system's job is to utilize a microphone (MAX9814 Electret Mic) to pick up the pitch of the string played. Once the signal is captured, it will be amplified and then connected to the microcontroller for further processing.

Control Subsystem: This control system will handle all computation/processing as well as the I/O for the whole system.

We'll use an ESP32 microcontroller for all data handling, and controlling the logic I/O for the rest of the systems. It will handle audio processing and filtering, determine the motor speed/direction to achieve the optimal tuning, update the UI display, and take in inputs from the buttons.

User-Interface Subsystem: This system will primarily be used for real-time audio tracking.

The primary component for this subsystem is the OLED display. When tuning, the user and system will need to verify the current pitch, and the OLED will display the current pitch in reference to our desired pitch. The Control unit will send data (I2C) to the display. When the pitch reaches our desired range, there will be a buzz or beep noise to indicate proper tuning.

Power Subsystem: The power system handles power and distributes to all the respective subsystems.

The components for this power unit is a Li-ion charger IC, Li-ion battery, a USB-c receptacle, as well as a buck/boost converter, and a Fuel gauge IC. The buck/boost converter will handle all power conversions, making sure that each component receives it's stable voltage. The Li-ion components will support the charging and allow power to be distributed.

Motor Subsystem: This motor system is in charge of turning the guitar pegs until the user reaches the desired pitch.

The primary component for the motor system will be a stepper motor which will handle precise movements while turning the pegs. The microcontroller will handle the motor control.

2.4 Tolerance Analysis

Once of the most important aspects of our project will be the way we amplify the audio signal captured by the microphone. We're planning to use the MAX9814 amplifier chip, which is specifically designed to use with electric condenser microphones. It includes a low-noise peramplifier, automatic gain control with selectable gain of 40 dB, 50 dB or 60dB. This range will ensure we can reliably amplify the microphone signals and work within the ranges of differing component tolerances. The main concern will be the supply voltage variations (2.7 to 5.5 V), which can impact noise.

3. Ethics and Safety

We will follow the IEEE and ACM Codes of Ethics by placing user safety first, being honest about our tuner's capabilities and limits (e.g., accuracy and torque), and promptly addressing any conditions that could endanger users or instruments. During development we will document results transparently, respect intellectual property, and avoid misrepresentation—core expectations in both codes—and we will enforce lab EHS practices for soldering, battery handling, and tool use. The Li-ion subsystem will use certified cells/packs and follow recognized battery standards—UL 1642 for cells, UL 2054 for battery packs, and IEC 62133 for portable secondary batteries—plus charge/current limiting, NTC temperature sensing, and protective housing. Anticipated risks include instrument damage from excessive torque, battery thermal events, and RF interference; mitigations include firmware torque/rate limits with watchdog timeouts, guarded rotating parts, fused/TVS-protected inputs, and EMC-conscious layout and shielding. We will provide clear user instructions for charging, storage, and safe use consistent with the above standards. In case of accidental or intentional misuse (e.g., forcing the coupler or using a damaged battery), the system will fail safe—disabling the motor, surfacing a fault on the display, and preventing further operation until conditions are safe.