

# DYNAMIC VIOLIN FINGERBOARD

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## **Abstract**

The dynamic violin fingerboard aids self-taught violinists in learning correct finger placements and rhythms. Users upload a MIDI file for a piece they would like to learn and configure the piece settings. A dynamic LED display laid on top of the fingerboard then illuminates the locations where the user should place their fingers at the appropriate times. Potentiometers measure the position of a finger placed along any of the 4 paths (strings) on the fingerboard. These measurements are turned into an accuracy metric that is provided to the user via an LCD display. This allows us to collect information on how accurate the placement is, rather than a simple yes or no as to whether they play the right note.

# Contents

- 1. Introduction ..... 1
  - 1.1 Problem..... 1
  - 1.2 Solution ..... 1
  - 1.3 Requirements..... 2
- 2. Design..... 3
  - 2.1 Power subsystem ..... 3
  - 2.2 Input subsystem..... 4
  - 2.3 Output subsystem ..... 4
  - 2.4 Tolerance analysis ..... 4
    - 2.4.1 Fingerboard unit resilience ..... 4
    - 2.4.2 Variation in power requirements..... 5
    - 2.4.3 Weight requirement ..... 5
- 3. Ethical considerations ..... 6
- References..... 7

# 1. Introduction

## 1.1 Problem

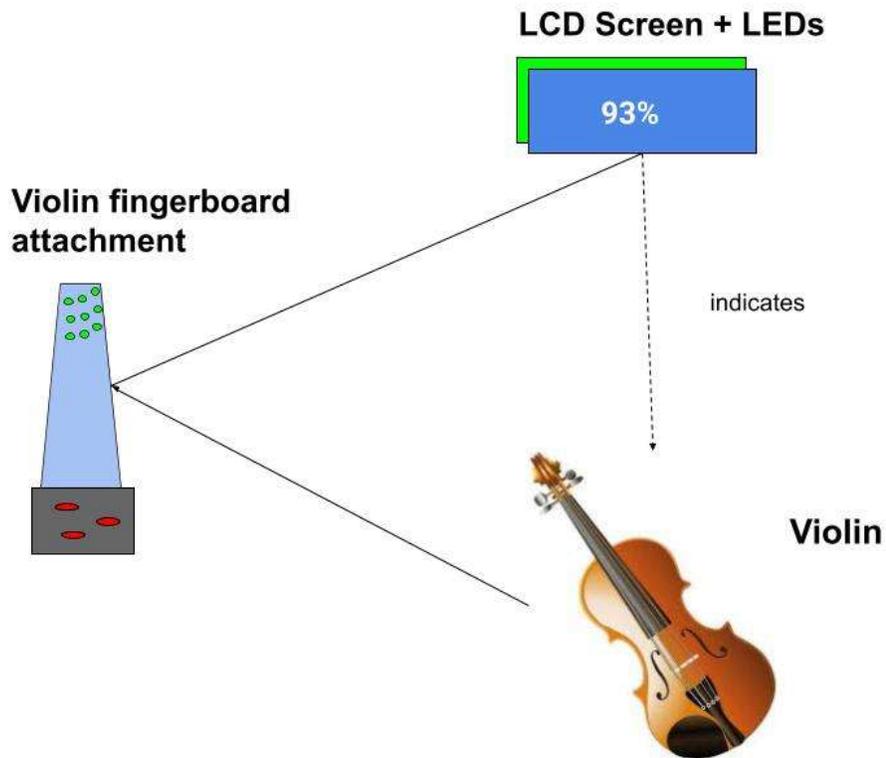
Most people would like to learn an instrument; however, not only are the instruments expensive, but the lessons are just as (if not more) costly. This also assumes lessons are even available where they live. For this reason, many people try to teach themselves how to play, either through experimentation or online resources. However, this path has a distinct lack of feedback that would help correct poor habits or otherwise incorrect playing.

## 1.2 Solution

Our project seeks to give those self-learning a violin an extra source of feedback with respect to finger placement (creating the notes) as well as the rhythm played. A dynamic LED display laid on top of the fingerboard would allow learners to better understand proper finger placement in addition to its relation to the specific note's duration.

Furthermore, by using linear/membrane potentiometers we measure the position of a finger placed along any of the 4 paths (strings) on the fingerboard. This allows us to collect information on how accurate the placement is, rather than a simple yes or no as to whether they play the right note.

To encourage building good habits and continuous practice, we would like to allow users to upload pieces they would like to learn. Thus, users will be allowed to upload files (MIDI) that can then be used on the fingerboard along with an adjustable tempo. This, paired with individual settings for full piece playthroughs and learning (only playing the next note after the user plays it) will help encourage good, accurate playing whilst making it fun.



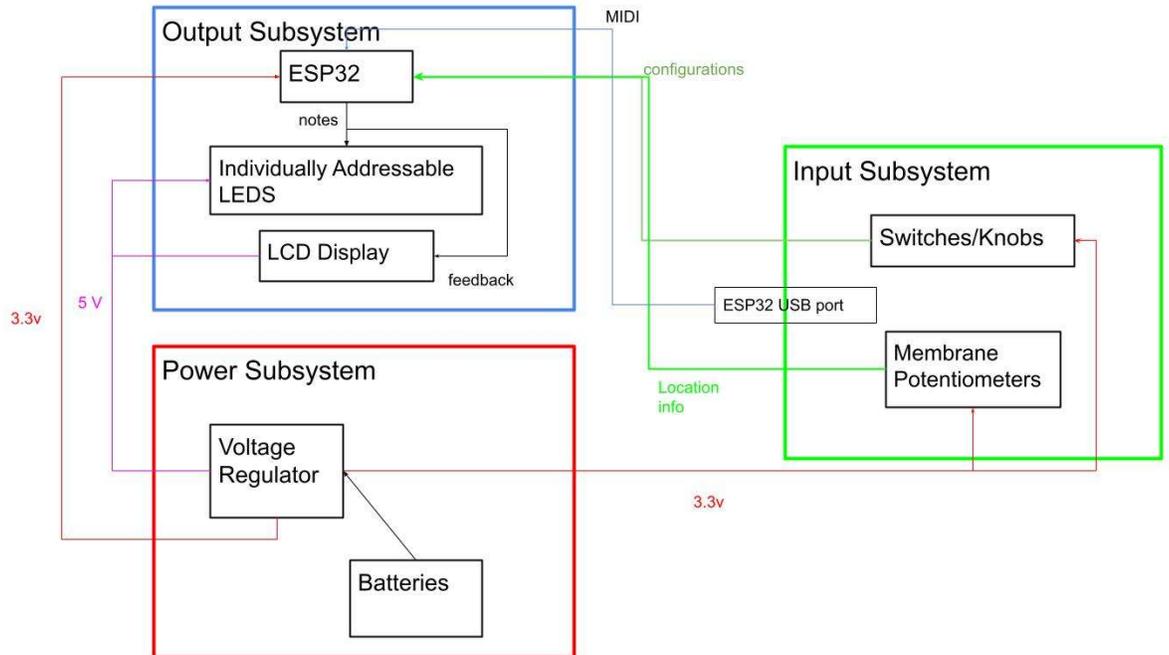
### 1.3 Requirements

This project will be considered successful if:

- The LEDs on the fingerboard turn on independently from each other in response to a signal from the control unit.
- A MIDI file less than 1 MB can be uploaded to the control unit and sets the control sequence for the fingerboard LEDs.
- Potentiometer membrane can detect finger placement within 2 mm and measurements are converted to an accuracy score that is provided to the user at the end of the piece.

If time permits, the following features will be added:

- Real-time accuracy feedback.
- Multiple songs can be uploaded to the controller at once and the user can choose which to play.



## 2 Design

The total weight of the entire project must not exceed 1lb to avoid disrupting the balance of the instrument or physically straining the user.

### 2.1 Power subsystem

The power subsystem will provide necessary power to all other subsystems and components.

It will provide the microcontroller with up to 250mA at 3V, and the LEDs and LCD with 500mA at 5V. A voltage regulator will constrain the provided voltage to within the safety tolerances of the individual parts as needed. Due to the differing voltage requirements for each subcircuit, they must remain relatively isolated. So, an increase in power consumption from one subcircuit should not cause the voltage supplied to the microcontroller to fall below 3 volts at any point (Espressif Systems, 2019). Similarly, an increased consumption should never allow the voltage of the LEDs to fall below 3 volts (Feztek).

The batteries of course provide the overall power, but the voltage regulator will help isolate the two separate the two different subcircuits (as they have different voltage requirements) while allowing for consistent flow.

## 2.2 Input subsystem

The input subsystem is responsible for managing user input. This includes the buttons and switches located on the main-body unit that the user uses to control configuration settings. Also included are the membrane potentiometers mounted on the fingerboard that measure user accuracy. The transfer of information will be routed through a microcontroller.

The input subsystem must be able to detect the finger placement of the user within 2mm and convert this as part of an accuracy score. The ESP32, while part of the output subsystem, does take input via the USB port. Thus, it should download a provided file within 5.5 seconds.

The switches and knobs will provide the output subsystem, specifically the ESP32 controller with the proper context under which to operate. It will allow the user to specify not only the tempo, but also what manner of play (progressive or runthrough) to proceed with. Meanwhile, the membrane potentiometers will also interface with the ESP32 to allow data tracking and, in the case of progressive play, continue the piece when sufficient accuracy is achieved.

## 2.3 Output subsystem

The output system is responsible for providing visual responses to the user. Individually addressable LEDs on the fingerboard guide the user through learning. A Liquid Crystal Display makes setting configurations more user-friendly and shows statistical information taken from a playing analysis computed by the microcontroller. In the context of musical performance, it is important to have a consistent tempo.

Therefore, we want the latency between the microcontroller and the LEDs to be self-consistent, within a variation tolerance of 7ms. Changes to the user-input settings will be reflected on the LCD display in under 1s. Final stats will be shown on the display within 10s of the piece finishing.

The ESP32 is the brain of the project and will analyze all the data to be communicated back to the user. This includes reading MIDI files and telling the user what input to provide. For this reason, it will control the LEDs via custom mapping to show finger positioning and give feedback on the LCD when a piece is over.

## 2.4 Tolerance analysis

### 2.4.1 Fingerboard unit resilience

The individually addressable LEDs and the membrane potentiometer are located on the fingerboard underneath the strings—where they will be consistently pressed down on by the strings and the user's fingers. This puts them at risk of advanced degradation. The potentiometer is designed for frequent contact, so it will likely be ok, but the LEDs are not. If this becomes an issue, the proposed solution is to offset the LEDs from the strings; far enough to not come in contact with the strings but close enough that it is still obvious which finger position each LED corresponds to.

### **2.4.2 Variation in power requirements**

The LEDs require 5V. The LCD will require either 5V or 3V depending on the specific display used. The microcontroller runs on 3V and will break if it receives 5V. We are currently planning on having separate batteries to handle the different voltage requirements. If that doesn't work out, a voltage regulator will step down the voltage to the level needed by the microcontroller.

### **2.4.3 Weight requirement**

Violins typically weigh about 500g, so even a moderately heavy system will affect the balance of the instrument. We will thus strive to make the entire project as lightweight as possible. Specific steps we are taking to reduce weight are considering button batteries (smaller than an AA battery), finding the lightest possible LCD, and streamlining the casing and mount.

### 3. Ethical considerations

Due to the nature of electrical systems, it can be inherently dangerous to keep a battery-operated device near people and on expensive equipment, as a fault in equipment could cause combustion leading to unjust harm to an individual and/or personal property, as outlined by the ACM (Association for Computing Machinery, 2026) 1.2 and IEEE (Institute of Electrical and Electronics Engineers, 2026) I.1. Thus, should there be a failure in the design or degradation over time, it is possible that the player or their instrument be harmed or severely injured.

As the designers, we are obligated to add redundancy both to prevent such accidents, as well as ways to mitigate accidents should they occur. This would include appropriately strong housing in case of any blown components and methods for heat dissipation to prevent overheating (which can cause warping in wood). The industry standard for electronics is generally plastic due to its electrical isolation and heat-resistant properties (AIP Precision Machining, 2025).

Furthermore, the ability for users to upload MIDI files without any sort of licensing or verification can enable, or otherwise encourage, the improper acquisition of creative works – specifically music. According to the US Copyright Office, derivative works made without permission from the original owner constitute copyright infringement (US Copyright Office, 2026). This can include MIDI files as they are generally treated as another medium expressing the same creative work. Sort of like uploading a digital copy of a physical book or translating it into a different language.

There seemingly isn't very much we can do to stop this without entirely removing the customizable uploads. The open-ended, almost open-source, aspect of this project rests on the proper conduct of the consumer when it comes to copyrighted works.

The self-sufficient nature of the product can potentially lead to decreased interest in receiving formal musical training. However, this product is not meant to be a replacement and treating it as would lead to overall worse musical performance across society.

## References

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