ECE 153A, Friday @ 4:00pm
Lab #3B

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INTRODUCTION

The purpose of this lab was to create a fully functional chromatic tuner. It should be able to measure musical notes accurately and quickly, as well as display an error estimate. The tuner should also be able to set a custom A4 frequency so it can be used to tune different instruments.

PART 1: DEVELOPMENT

In the last lab (3A), we optimized the speed of the frequency calculation by using a lookup table with precomputed sine and cosine values. Building upon this, our focus expanded in this lab to add a user interface and provide additional functionalities. The additional functionality includes presenting information about the nearest note, the deviation from the nearest note, and the octave of the note.

Given the emphasis on the user interface of our chromatic tuner, we introduced a home screen with a menu system to allow for easy navigation to the various modes of operation. The design of the home screen drew inspiration from the pattern developed in Lab 2B, providing a visually pleasing idle state for our chromatic tuner when not in use.

During active use, we streamlined the displayed information to include only essential details for the end user. This includes a large frequency and its corresponding note readout, along with a visual representation indicating the deviation from the true note. The deviation indicator turns green when the played sound aligns with the specified frequency range for the particular note.

To enhance user interaction, we incorporated a rotary encoder into this lab, complementing the existing buttons integrated with our FPGA. This way we can provide a more intuitive experience to the end user.

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One of the function modes was a graphical representation of the Fast Fourier Transform (FFT). This display includes information about the highest recorded frequency, bin spacing, and a histogram illustrating the characteristics of the received sound data.

PART 2: TESTING

To assess the performance of our chromatic tuner, we targeted three primary test cases. The first case involved an edge scenario where the frequency fell between two notes. This case helped us address user interface issues related to oscillating between two notes. The second case focused on a scenario where the frequency did not precisely match any single note, allowing us to observe the behavior of the accuracy bar in action. The third case, where the frequency precisely matched a note, allowed us to evaluate the overall functionality when a correct note was played. In executing the tests for the chromatic tuner, we determined that playing frequencies from an online frequency generator through our phone directly into the microphone hole on the board yielded the most consistent and reproducible results. Attempting to use a pair of headphones to generate frequencies resulted in erratic variations in the notes detected by the tuner. This discrepancy is likely attributed to the fact that contemporary headphones often produce stereo audio rather than mono audio. The stereo audio setup would require presenting both sides of the audio to the microphone, posing challenges in capturing accurate data. Therefore, we found that the phone speaker setup provided the most reliable and effective testing method for our chromatic tuner.

PART 3: RESULTS

Completing this lab proved relatively straightforward, thanks to its foundation on multiple preceding labs. Apart from the histogram, the most labor-intensive aspect of the lab was the

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process of writing to the display. Nearly all functions involving the display involved directly coloring or positioning based on pixel locations. We did encounter one issue that was particularly annoying to debug, the histogram appeared frozen at certain frequencies. This was due to "ghosting" because of the way that we were coloring the screen to refresh and clear previous rectangles when painting new ones. We didn't get this completely fixed and it still propped up once in a while.

During the tuner demonstration, an oversight became apparent as we had not initially accounted for testing our tuner across multiple octaves. Fortunately, we were able to validate the functionality by accessing the octave selector and opting for octave seven, thus enabling sensitivity to higher frequencies.

In summary, while our tuner demonstrated functionality, several issues arose, including limitations in the main tuner's range, occasional freezing of the histogram, and intermittent glitches with the potentiometer. These challenges notwithstanding, the overall success of the tuner showcased the effectiveness of building upon prior lab experiences.