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Lab3B - The Chromatic Tuner

Purpose and expected goals of the lab

The goal of this lab is to create a chromatic tuner that is competitive with current musical tuners on the market. Since this lab is treated like a marketable product, it should be able to measure musical notes accurately and quickly with an feasible user interface. Tuner shall be equipped with 5 standard features such as: a menu for octaves 2 - 7, a note display, an error estimate, A4 Frequency tuner, a Histogram display, and integration of buttons and an encoder to operate the program. The user interface shall have an intuitive, stable design and accuracy throughout several ranges of frequencies.

Methodology

Lab 3A coached us on the fundamentals of creating accurate and efficient FFT algorithms. This was done by improving the sampling rates for better resolutions in specific frequency ranges. Since the goal is to create an accurate and efficient product, we improved our FFT algorithm by downsampling from 4K samples, in order to be able to read out higher frequencies.

Table 1 below includes the range of each octave for the Chromatic Tuner.

	Octave 2	**Octave 3**	**Octave 4**	**Octave 5**	**Octave 6**	**Octave 7**
Sampling	4096	2048	1024	512	256	128
Range (Hz)	94-188	188-375	375-750	750-1.5k	1.5k-3k	3k-6k

Table 1. FFT Octaves

The Encoder and QFSM from Lab 2B were used to navigate through the user interface of the Chromatic. Twisting the Encoder lets the user select options or change values. Pressing down on the Encoder changes what is displayed on the screen. The different display options were to view the A4 Frequency view, the Menu view, the Histogram view, and the Tuner view. Each view has its own unique QFSM. Refer to Figure 1 for the software flow of the program.

When the frequency was measured, the proper note and error bar would need to be calculated. This was done using the following formulas and was implemented in the note.c file.

$$f = 440Hz * 2^{\frac{(n-9)}{12}+k-4}$$

Equation 1. Frequency vs. Note and Octave

$$c = 1200 \times \log_2(f_1/f_0)$$

Equation 2. Equation for cent error

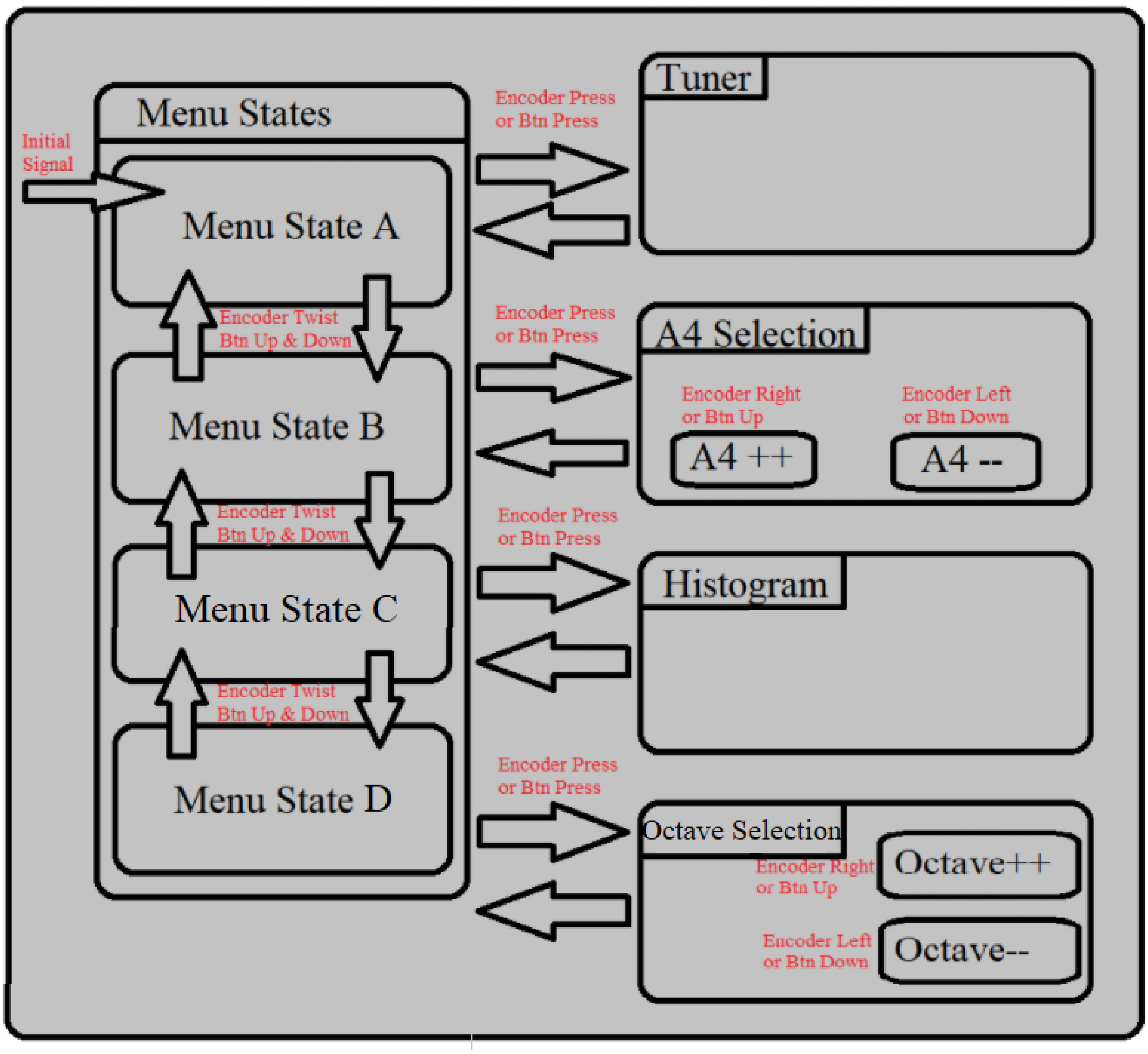

Figure 1. QFSM Hierarchical View

Lastly, the debug method and to test the code requires the following steps:

1. After compiling the code, the LCD will immediately show the initial menu view. From this menu you may twist the Encoder or press the buttons on the board to navigate between the A4 Frequency view or the Tuner view.
    a. The Tuner view is the main view of the program where the microphone begins to collect data. This setup is automatic when it measures the octave which hears the frequency sound near the microphone on the board to measure the frequency emitted. Pressing down on the Encoder returns to the initial menu view.
    b. In the A4 Frequency view, you may twist the Encoder to change the value of the A4 Frequency, then return to the initial view.
    c. In the Histogram view, you may twist the Encoder to change the octave, while it displays a real time histogram of what the microphone picks up. Pushing down on the encoder will result in returning to the initial view.
    d. The Octave Selection view has the flexibility of changing the octave to your choosing. At this point you may twist the Encoder to change the Octave, or play a frequency sound near the microphone on the board to measure the frequency emitted. Pressing down on the Encoder returns to the initial menu view.
2. To test frequencies this website is used: https://www.szynalski.com/tone-generator/

Results

The Chromatic Tuner created in this project resulted in an accurate and easy to use product with an intuitive user interface. The Tuner uses a single screen interface that can change screens using the Encoder & Button, and receives the frequency input from the on-board microphone. The FFT implemented is quick enough for a fluid measurement, and the UI design is polished and clear. The Tuner runs very well with near precise accuracy. The A4 tuning feature also works in this Tuner, and changes accordingly with the frequency measurement screens. Based on the intuitive user interface and fluid design, this could possibly become a sellable product. One implementation that could potentially make this product better would be even higher accuracy for the low end frequencies. Another flaw that this design had was that it was very sensitive to high frequency in the main tuner view, as any small change would result in the octave to change down back.