Pirate Autotuna

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EECS 700 Final Project

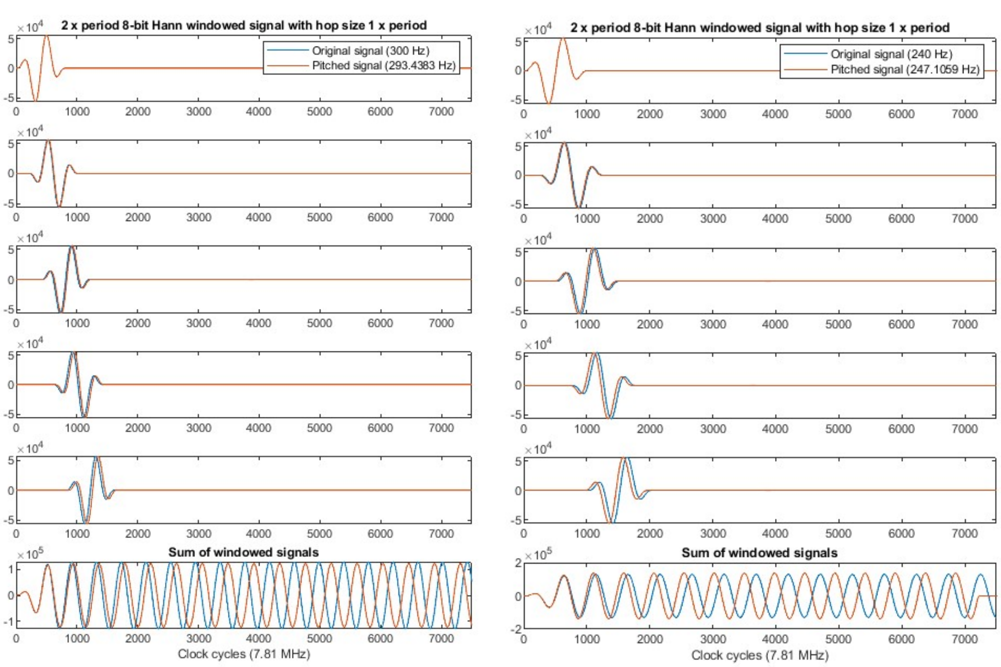
General Overview of Method

Decimation: The sampling frequency used is 61.035 kHz which is higher than Nyquist for 22 kHz, the limit of human hearing). This frequency was chosen as a convenient decimation of the ADC clock rate by 2048. This is performed by 12 cascaded HBFs. With the output of the last latched to the clock of the 11th.

Detection: The period of the input signal is detected by counting the number of clock cycles between negative to positive zero crossings.

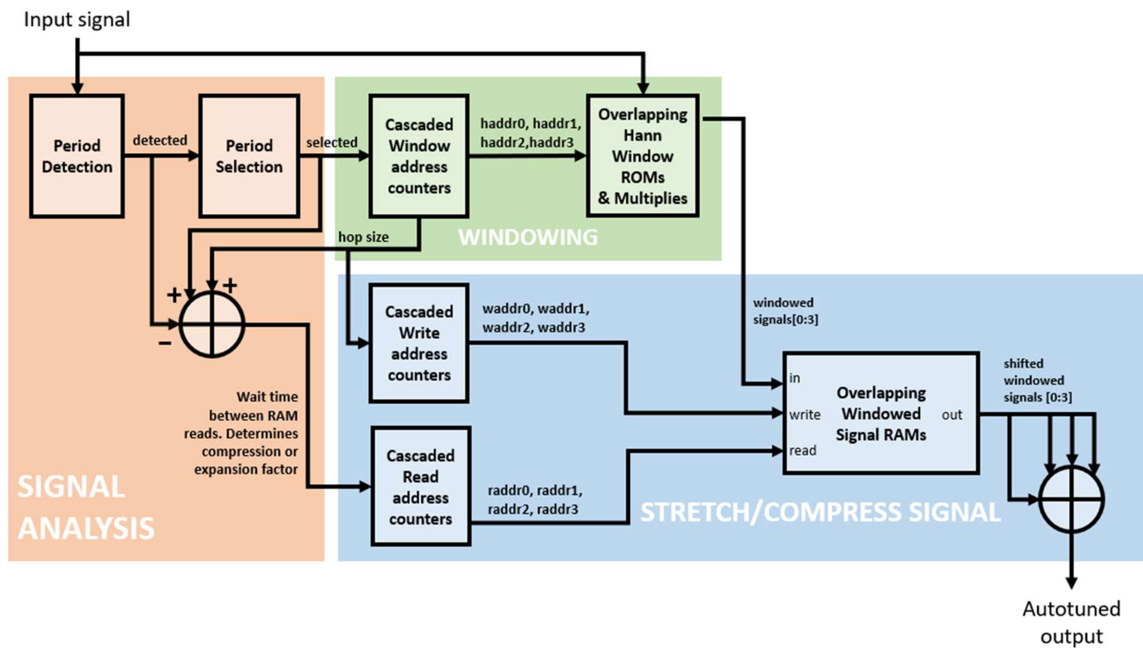
Selection: A 2 ROMs are used for note selection. One contains values for the period of allowable notes. The second contains the mid points between these periods. The detected period is input to a stage of parallel comparators which sort the detected period into a period bin, which corresponds to a single allowable note in the scale.

Correction: The method used to perform pitch shifting for this project is the Time-Domain Pitch-Synchronous Overlap Add (TD-PSOLA) Algorithm. This approach uses a variable window size that is dependent on the detected period of the input signal. The signal is chopped up into overlapping segments which are then windowed, shifted, and added. In order to preserve the original signal structure, a large degree of overlap was used (half the window size). This is the hop size referred to in the diagrams below.



Left: Time compressed output signal (Frequency up-shift), Right: Time stretched output signal (Frequency down-shift)

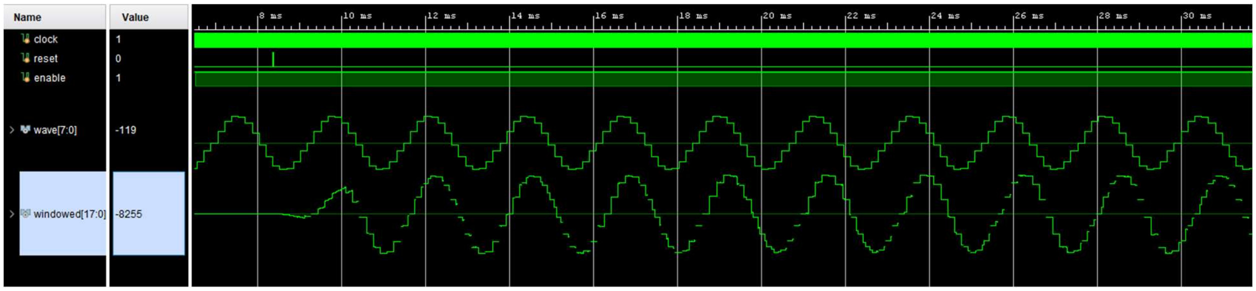
Design Diagram:



Results

Frequency detection and selection Vivado simulation

447 Hz test signal, 61.035 kHz clock frequency. Since there are at most 3 overlapping windows (when the signal is compressed), 3 RAMs are necessary to store the windowed signal.



447 Hz tuned to 440 Hz.

Autotune ILA results

AVB control listening to the original signal or the pitched signal

ILA original signal and pitched signal.

AVB control the tone. Give equation here.

HOW TO USE:

- Open the project: Pirate Autotuna
- To see simulation results, run simulation.
- To see hardware results:
    - Generate the bitstream and program the hardware.
    - The address counters for writing and reading to RAM need to be manually initiated, at least 15 ms after the hardware is programmed: long enough for the longest potential period to be detected. To initiate, in Linux cmd line, write 1XXXXXXX to address 0, then subsequently write 0XXXXXXX to address 0. This toggles the reset to the address counters.
    - ILA Results: The probe[31:16] is the signal input probe, and probe[15:0] is the autotuned output probe.
    - Sound: You can listen to either the input signal or the autotuned output. In Linux cmd line, writing 01XXXXXX to address 0 plays the input tone. Writing 02XXXXXX to address 0 plays the autotuned tone. The sound defaults to playing nothing.
    - You can control the tone input by writing to address 2. _ _ _ XXXXX (bits 31:20) controls the step size of the DDS, XXX_ _ XXX (bits 19:12) control the limit, and XXXXX_ _ X (bits 11:4) control the amplitude. By default, the tone is set to 447 Hz, which autotunes to 440 Hz.

Some references:

[FULLTEXT01.pdf (diva-portal.org)]

[TD-PSOLA …the hard way (speech.zone)]