

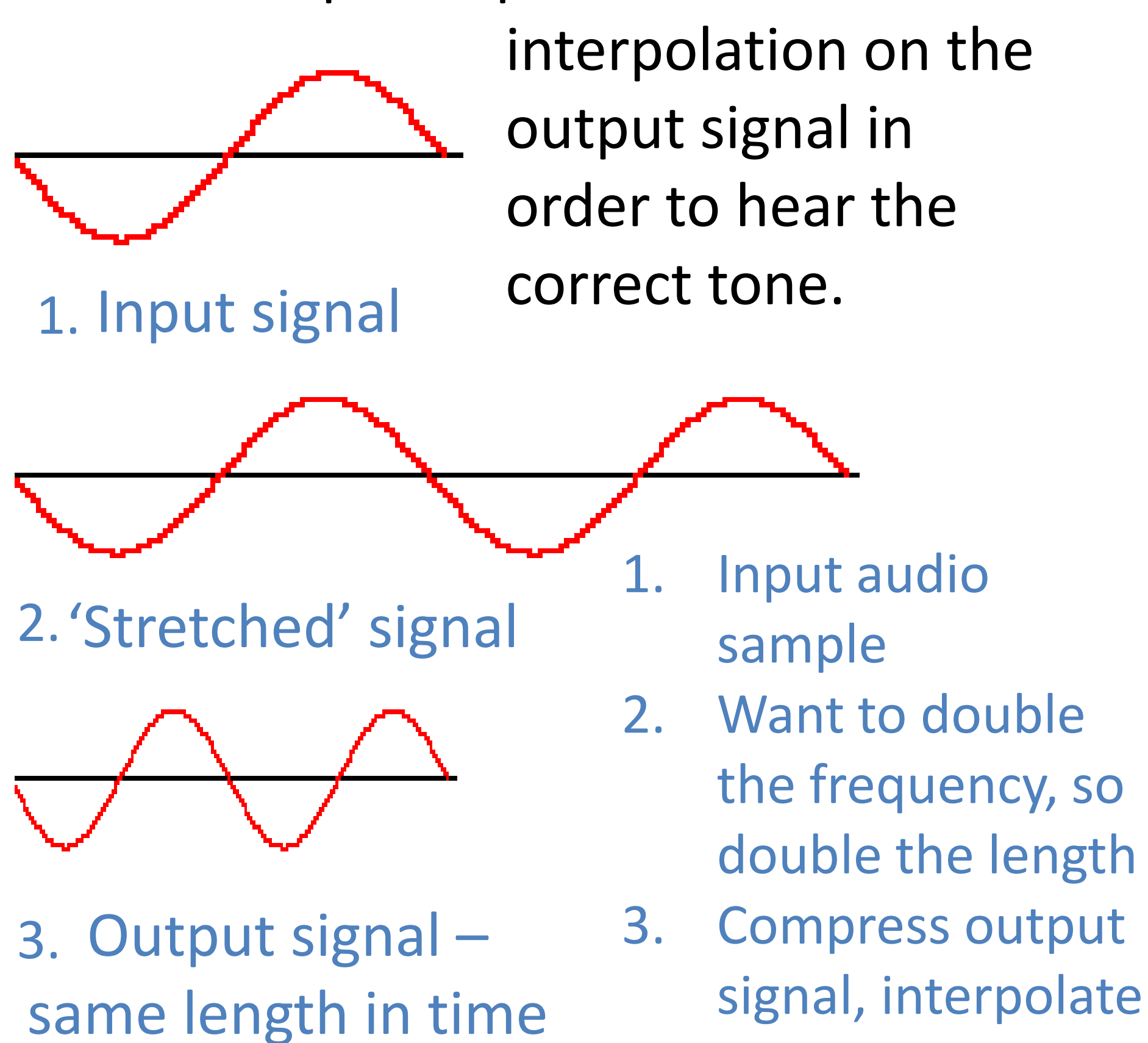
Introduction

The purpose of the ToneShift device is to use digital signal processing methods to modulate electric guitar audio signals. The output of the electric guitar is connected to the device via Piezo pickups, which allow individual strings to be manipulated separately.

The ToneShift permits the user to alter the tone of their guitar without physically tuning the instrument. The device has two main functions, a preset standard tuning selection and a simulated capo function.

Algorithm Overview

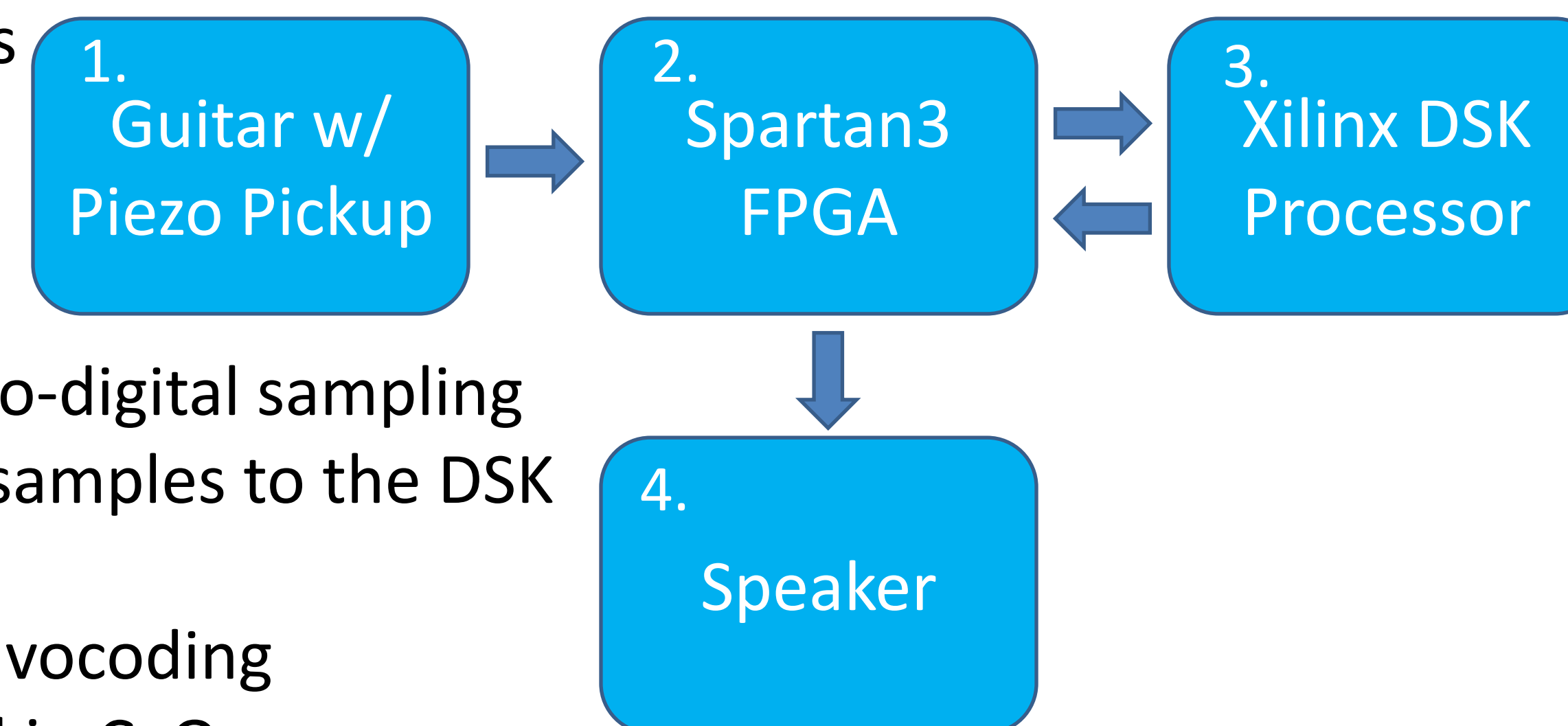
Phase vocoding is a common technique used in DSP. The idea is to stretch or compress an incoming audio signal depending on whether a higher or lower tone is desired. Once the correct output frequency is chosen, the vocoder matches its length to that of the input, allowing them to play for the same duration of time. The last step is to perform linear



Design Implementation

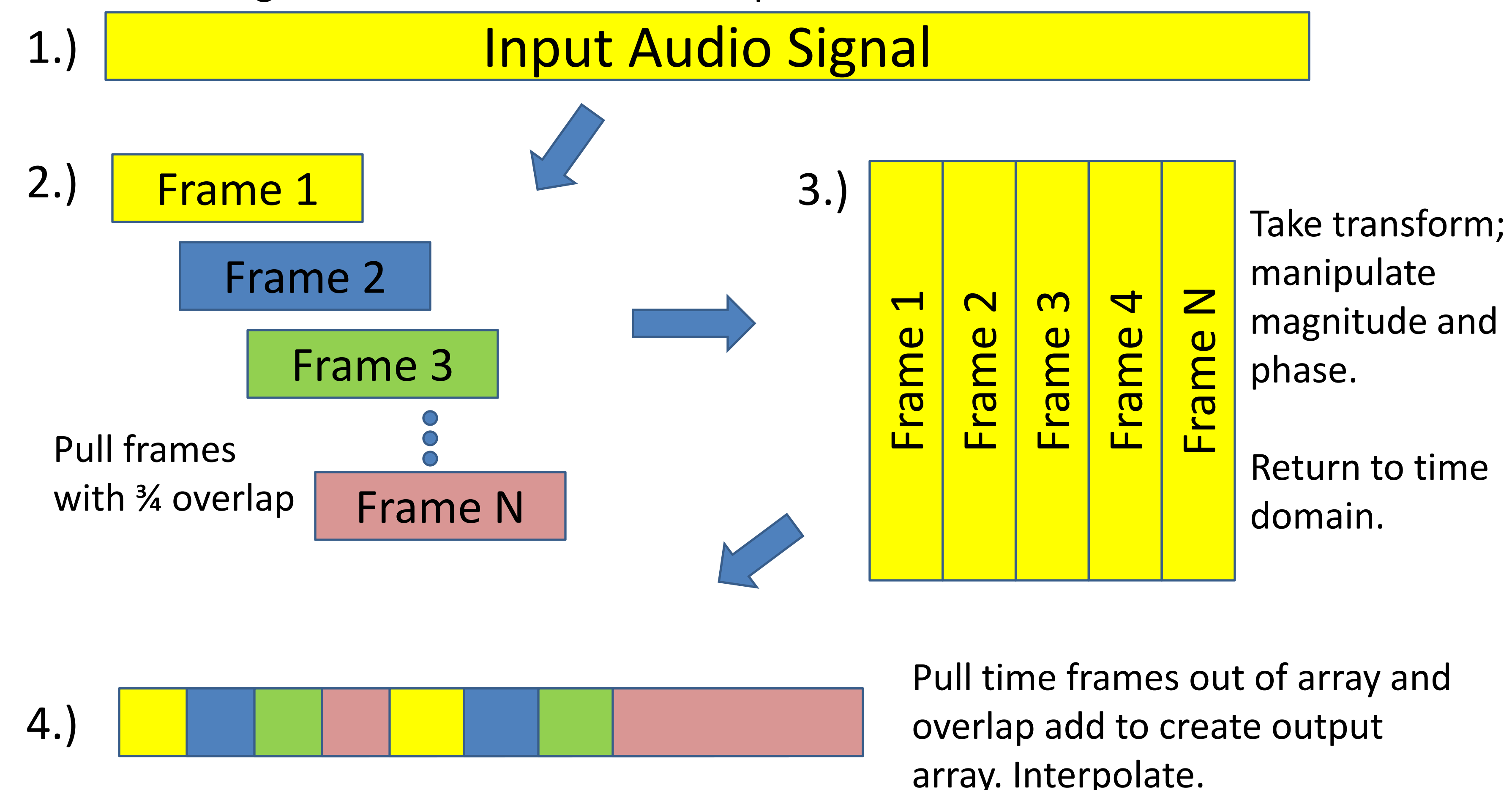
Equipment and Implementation

1. The Piezo pickup obtains audio information from the six individual strings of the guitar.
2. FPGA performs analog-to-digital sampling and sends the digitized samples to the DSK via interrupts.
3. DSK executes the phase vocoding algorithm, implemented in C. Once complete, the shifted data is transmitted back to the FPGA.
4. FPGA performs digital-to-analog conversion and outputs to speakers.



Phase Vocoding Process

1. Given a digitized audio sample, break into overlapping frames according to "hop size."
2. Take the STFT of individual frames and place them into an array.
3. Convert the complex number pairs to polar form; compare magnitude and phase information of adjacent frames. Return to complex form.
4. Take the ISTFT of each frame and overlap-add the real time values in the same manner they were removed from the input array. Perform linear interpolation on this signal to observe desired output.



Matlab vs. C

One of the most difficult aspects of this project was the contrast between Matlab and C. The algorithm was written and tested in Matlab to ensure its functionality. Matlab performs operations in 64-bit floating point. This allows for great precision and little control from the programmer. Our system used a 32-bit processor and ran inefficiently with floating point arithmetic. A great portion of our project was dealing with the precision loss and representation constraints in C.

Future Applications

Other similar applications to our current device may include:

- **Auto-Tuning Guitar** - Finds closest frequency and outputs correct tone
- **Effects and Distortion Control** - Easily add effects to guitar output
- **Custom Tuning** - Allow user to shift individual strings by desired amount

Contact Information

Please contact guitartuner@umich.edu with questions regarding this project.

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