Digital Effects Box for Guitar
Design Overview

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6.111 Final Project
Design Goals

• Real-time processing of audio signal
• Create effects in the frequency domain
• Visual interface for effect manipulation
• Visualization of effect on spectrum
FFT Module

- FFT module is defined by two parameters: sample rate and number of samples
- Output is magnitude of frequency band, where:
  \[ \text{bandwidth} = \frac{\text{Sample Rate}}{2 \times \text{Number of Samples}} \]
- Use 8 instances of Xilinx 128-pt FFT
- Each instance takes in 128 samples from AC97 module at a different sampling rate, from 384 Hz - 48 kHz
- Each FFT corresponds to one octave of tones
FFT Module con’t

- Musical pitch is logarithmic in frequency
- Resolution of frequency bands needs to be much higher at lower frequencies, on the order of 3 Hz
- At higher frequencies, resolution only needs to be on the order of 500Hz
Buffers

- Data is fed into buffers from AC97 module
- Buffers control sampling rate of data
- Send control signal to FFT
Note Array
Note Array

- 96 value array, corresponding to all notes over 8 octaves
- Will receive magnitude information for each possible note, in order from highest to lowest, from each FFT
- Serves as a “pitch-corrector”
- Records how long a certain pitch has been active
- Outputs magnitudes and timing information for a specified order of frequencies
FX

- Performs arithmetic on magnitude and frequency
- Outputs to Function Generator
- Exact frequency values for notes read from BRAM
- Controlled by user through GUI
  - effect
  - intensity
  - speed
Effect Options

- Vibrato
- Pitch Bend
- Arpeggiator
- Harmonizer
- Delay
Function Generator

- Calculates $A \sin(\omega n)$, where $A$ is the magnitude received from the FX module
- Receives values for $\sin(\omega n)$ from LUT

Output from function generator is sampled at 48kHz, so to create different frequencies, a $48000/N$ Hz sine function is sampled at $N/\dot{f}$ points, where $N$ is the number of samples and $\dot{f}$ is the desired frequency.
Adder and Delay
Adder and Delay

- Sums together outputs from Function Generator and any delayed signals
- Delay length determined by user in GUI
- Maximum delay is 4 seconds
- Outputs to AC97 module @ 48 kHz
GUI

- Visualize effect options
- Input from labkit buttons
- Outputs parameters to FX module
- Displays wet and dry spectra
Tying it all together