Digital Effects Box for Guitar
6.111 Final Project Abstract

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Our 6.111 Final Project is a Digital Sound Effects Processor for guitar, or any other electronic instrument with a line-level signal. Traditionally, guitar/instrument effects were created with analog circuits and components, mainly in the form of discrete "pedals" which were chained together from source to amplifier to modify the output. This creates, among other things, noise, delay, and signal loss. By digitizing the effects and combining them into a single I/O form factor, we can mitigate the problems introduced in analog processing. Additionally, effects that are not possible using analog components can be created in the digital domain.

The backbone of our effects processing is a Fast Fourier Transform module which allows us to quickly determine the frequency content of the input signal and modify specific frequencies individually. This would be extremely difficult to implement with analog components, and certainly not fast enough to perform real-time processing.

Another benefit to processing in the digital domain is that the processor has access to memory, allowing for such effects as reverb and lengthy delay. Because we are sampling at 48kHz, the block RAM on the FPGA will not be sufficient to hold all of the data. As a result, we will make use of the ZBT RAM on the labkit. At a sample rate of 48kHz and a resolution of 18 bits, we can store up to 37 seconds of sound data in the ZBT RAM, although we will only realistically need to store less than 10 seconds of data.

In addition to the delay effects and the effects created with the FFT, there are other, simpler effects that can be implemented using FIR filters. Some such effects are flanging, which takes two identical signals, and delays one by a very small and increasing amount, and then combines it with the original; wah-wah, which shifts the frequency response curve of the input signal; chorus, which outputs the original signal plus a copy that is slightly delayed to create a "multi-voice" effect; and distortion, which amplifies the sound above its operating voltage, and then clips the peaks. Besides for this short list, other effects are possible, and part of the design will allow for tweaking to create new effects.

We will also be including a GUI to select which effects will be used with the current inputs, what the output level of the effect will be, and also to show the spectrum of the signal and its modification by the processor.

The team consists of Mr. Moskwa and Mr. Senft-Grupp, who will be dividing the work into two sections. Mr. Moskwa will be handling the hardware design with regards to the FIR filters, and Mr. Senft-Grupp will be designing the GUI and the memory interface module. Both will work on the more difficult aspect of the project, the FFT, each contributing research and ideas.