Verilog Guitar Multi-Effects Processor

6.111 Final Project Checklist | Haris Brkic | Fall 2017

The commitment:

- Playing the guitar through the FPGA without a significant drop in audio quality (with no effects)
  - This requires the implementation of the *Signal Processor* and *Amp Processor*.
  - *Signal Processor* converts the input guitar signal into a signal usable by the AC97.
  - *Amp Processor* converts the output of the AC97 into a signal compatible with a guitar amplifier.
- Working *distortion* and *delay* effects (separately). This also requires a working *Effects Controller* module.
  - *Effects Controller* is a FSM that takes in the digitized signal and effect parameters, applies the appropriate effects to the digitized signal, and outputs the resulting signal.
  - *Distortion* hard clips the input signal producing a warm or gritty sound.
  - *Delay* reproduces the input signal with a slight-time delay.

The goal:

- Implementing the simpler effects: *distortion*, *delay*, *looper*, *chorus*, *wah-wah*
  - *Looper* records a phrase and plays it in a loop. It also allows multiple tracks to be recorded on top of each other.
  - *Chorus* creates the sensation of hearing multiple guitars by splitting the signal, delaying one of the copies and joining them back together.
  - *Wah-wah* makes vowel-like sounds by implementing a moving bandpass filter.

- A graphical representation of the pedalboard
    - The *Graphics* module will indicate which of the pedals are being used and what parameters they are set to on a screen.
- Possible to use multiple effects at the same time
    - *Effects Controller* must pass the input signal through a proper chain of effects because the effects must be applied in a certain order to avoid producing undesired effects.

Stretch goal:

- All the effects work properly including the complex effects (*phaser*, *pitch shifter*, *reverb*)
    - *Phaser* applies a cascaded 2^{nd} order notch filter (with a low quality factor) to the input sound and produces slight rippling effect in the sound.
    - *Pitch Shifter* raises or lowers the pitch of the notes played. It achieves this by sample rate conversion.
    - *Reverb* simulates spacious sounds by implements a computationally expensive algorithm (GVerb) that has the same behavior as many gradually decaying echoes.
- Possible to use most of the effects at the same time without any issues
    - Most available digital processors have a limit on the number of effects that can be applied because the effects interfere with each other.
- Visually appealing graphical representation (UI) of the pedalboard
    - Represent the effects as an image of a real pedalboard or guitar amplifier.