Guitar Effects Generator Using DSP
Functional Description and Complete System Block Diagram

Alex Czubak
Gorav Raheja

Advisor: Dr. Thomas L. Stewart

Introduction

Recording artists and musicians have implemented audio effects into their live and recorded repertoire. Analog methods have all but disappeared, allowing digital signal processors to take their place. This project specifically entails creating effects on a signal processor for guitar. Musical notes shall be generated from a guitar and sent to a processor for effects generation. The processor shall contain a number of digital filters that create the effects. These effects shall be user-driven, so undesired effects can be bypassed and desired effects utilized. Then the processor shall send the signal to a guitar amplifier and speaker for aural reproduction. Research will provide which effects shall be designed. The implementation of this project has two phases: Phase I consisting of adding effects to pre-recorded guitar notes, and Phase II consisting of real-time effects generation.

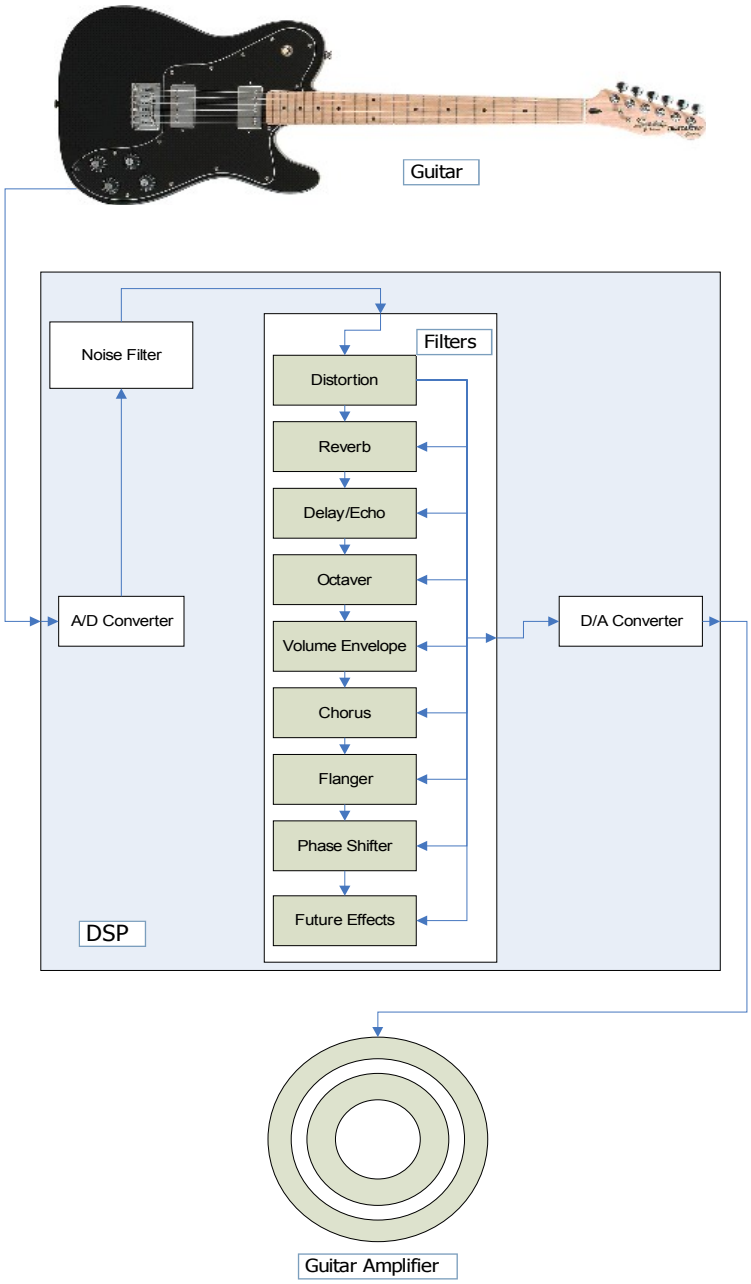
Goals

The project has the following goals to keep it moving forward:

- Filter out single-coil pickup noise (approx. 60 Hz)
- All effects after the noise filter are user-defined, meaning that effects not wanted by the user shall be bypassed
- A distortion model that boosts and clips the signal at specific maximum and minimum values
- Create audio reverberation simulation
- Create digital delay and echo
- Change the signal to be an octave higher than played
- Generate an automatic volume swell that is modified by how fast it reaches maximum volume
- Produce Chorus effect to make the guitar sound like multiple guitars
- Create a whooshing sound within the signal using either delay lines (flanging) or shifting the phase of the signal (phaser)

Other effects may be added later on if time allows it. Possible future effects are acoustic simulation, humbucker modeling for single-coil pickups, single-coil modeling for humbucker pickups, tube-like distortion, and auto-wah.

High-Level Block Diagram



The signal comes from the guitar and goes to the DSP. It is converted to a digital signal first, then it passes through a noise filter. From the noise filter, it goes to the user-defined effects filters. After this, the modified signal is converted back to analog and is sent to the guitar amplifier for sound generation.

Guitar Description

Two guitars will be the primary signal generators. One is a Squier Stratocaster, and the other is a Squier Telecaster Custom. The Stratocaster contains three single-coil pickups; these pickups present a lean and clear sound, but they produce a 60-Hz hum that will be eliminated by the processor. The Telecaster contains two humbucker pickups; essentially two single-coils with opposite polarities to cancel the hum, the humbucker outputs a warmer and broader sound.

DSP Description

The DSP contains converters so that the signal can become digitized for effects processing and then return to analog form for audio representation – an A/D converter and a D/A converter. A noise filter follows the A/D converter, eliminating the noise inherent in single-coil pickups. The effects filters are connected to allow certain effects to be utilized when selected and other effects to be bypassed when not chosen. The number of effects planned are eight, but time may allow for more effects filters to be designed. The effects filters lead to the D/A converter.

Guitar Amplifier Description

A Fender Frontman 15R Guitar Amplifier shall be used to output the audio. It has a reverberation potentiometer on it, but this will be set to 0 so that the designed reverberation effects can be tested. It also has a distortion channel, but this will be ignored to test out the designed filter.

References

Oboril, David, Miroslav Balik, et al. Proceedings of the COST G-6 Conference on Digital Audio Effects. "Modelling Digital Musical Effects for Signal Processors, Based on Real Effect Manifestation Analysis." December 7-9, 2000: Verona, Italy.

Karjalainen, Matti, Henri Penttinen and Vesa Valimaki. IEEE. "Acoustic Sound from the Electric Guitar Using DSP Techniques." 2000: Helsinki, Finland.

Fernandez-Cid, Pablo and Javier Casajus-Quiros. IEEE. "Multiband Approach to Digital Audio FX." 2000: Madrid, Spain.

Verfaille, Vincent, Udo Zolzer and Daniel Arfib. IEEE Transactions on Audio, Speech, and Lauguage Processing. "Adaptive Digital Audio Effects (A-DAFx): A New Class of Sound Transformations." Volume 14, Number 5. September 2006.

Qi, Yuting, John William Paisley and Lawrence Carin. IEEE Transactions on Audio, Speech, and Language Processing. "Music Analysis Using Hidden Markov Mixture Models." Volume 55, Number 11. November 2007.

Keen, R.G. Guitar Effects FAQ. May 20, 2000. <http://www.geofex.com/effxfaq/fxfaq.html>

Caputi, Mauro J. IEEE. "Developing Real-Time Digital Audio Effects for Electric Guitar in an Introductory Digital Signal Processing Class." 1998. <http://www.ewh.ieee.org/soc/es/Nov1998/01/BEGIN.HTM>

Stewart, Dr. Thomas L. Bradley University. Professor and Advisor. October 18, 2007.