Developing Digital Audio Effects in Real Time for Acoustic Guitar using Simulink Model

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***Abstract* - The processing of digital audio effects have many applications in different fields. This paper mainly focuses on developing and designing of the guitar multi-effects using a Simulink model. Music industries commonly uses the Audio effects for enhancing the music quality. Earlier the music industry was used to record the music to improve the quality of the music by adding the different effects that he or she wants. But this paper includes designing of real time audio effects in digital domain using Simulink Model for high speed and low cost.**

Simulink Tool consists of Aerospace Blockset, Audio System Toolbox, Communication System Toolbox, DSP System Toolbox, Embedded Coder, LTE HDL Toolbox, Powertrain Blockset, SimEvents, Simscape, Stateflow,Vision HDL Toolbox which is used in many applications.

Keywords- Guitar effects, Simulink model, Simulink Tool.

I. INTRODUCTION

There has been a huge amount of work done in the field of digital audio signal processing. Our goal is to apply Simulink knowledge to real-time Acoustic guitar effects and to boost the Acoustic guitar sound. Earlier, analog electronic methods were used for the implementation of these effects. But it can be implemented extremely well using digital domain. By knowing the basic knowledge about audio signal processing and algorithm one can create there own audio effects for guitar in digital domain using Simulink model.

Nowadays, these algorithms are commonly used in portable audio players,all kinds of consumer devices like smart-phones and videogame consoles, electronic or virtual musical instrument, professional or home music production studios. Digital audio effects are nothing but the system used to increase the quality of the original real-time audio signal.

In the past they have done with sound processing where it deals with the modification of sound using different types of processors and digital filters for pre-recorded audio clip. Sound synthesis is the creation of application-specific sounds using software/hardware implementation. But in this, cost is more and for synthesis one should design the synthesizer for respective use. Analog approach is unlimited which means it has higher resolution without proper quality.

II. ABOUT MATLAB &SIMULINK

MATLAB is aenvironment with numerical computation and is a programming language which was developed by MathWorks. It is alanguage with good performance andhence it is used for visualization, integrating computation, technical computing and also used for programming where solutions are expressed in mathematical notation.

MATLAB also includesplotting the functions and data, creation of user interfaces, matrix manipulationand interfacing the implemented algorithms with programs written in other languages.

A. Uses of MATLAB are:

- It is used in Math and computation.
- It is used in Algorithm development.
- It is used in Modelling, simulation and prototyping.
- It is used in Data analysis, exploration and visualization.
- It is used in Scientific and engineering graphics.
- It is used in Application development, including Graphical User Interface building .

Simulink is a MATLAB-based programming environment for plotting graphs, modelling, analyzing multidomain syatems and also for simulating. It has personalizedgraphical block diagramming tool and a set of block libraries. It includesintegration with the other MATLAB environment and it can drive MATLAB or it can be produced from MATLAB.

Simulink can be used inautomatic control and digital signal processingfor model-based design as well as multidomain simulation. Any type of simulation can be done in Simulink and also model can be simulatedin the environment at any point.

B. Characteristics of Simulink

- Graphical editor were used to manageand build block diagrams.
- Simulink has pre-established blocks of Libraries for modeling discrete-time systems continuous-timesystems.
- Simulation engine consists of fixed-step and variable-step ordinary differential equation solvers.
- Simulation results can be viewed by Scopes and data displays.
- To manage model files and data, simulink has Project and data management tools to manage model files and data.
- Legacy Code Tool are used to import C and C++ code into Simulink models.

III. DETAILED DESCRIPTION ABOUT AUDIO EFFECTS

The main goal of this project is to implement different audio effects for the guitar. Few effects are implemented in real-time using simulink.Artificially created sound is called sound effect which can be used in television shows, during live performances, content of the films, music, video games or other media. An audio effect is basically the alteration of audio to make it sound more fascinating.The usage of effects for modification of sound has change over the centuries.

This paper deals with the theory, design specification and implementation of desired effects to input audio signal. MATLAB based design approach helps to easily configure desired audio effects by varying the values of predefined simulink blocks. Simulink parameters, control the transfer function for the desired guitar audio effects. Instead of doing mathematical formulation , the parameters can be set with trial and error and with fine tuning, excellent audio effects are observed.

The human observation of these audio effects leads to a classification, the following are some of the guitar audio effects simulated through MATLAB.

A. Multiple Echo

Multiple Echo is the repetation of original sound multiple times with certain delay and attenuation in it. This can also be defined as reflection of the original sound after hitting the object or any surface.

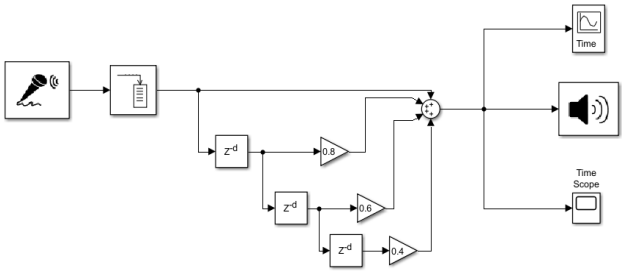

Fig 1- Simulink model of multiple echo

A. Blocks Specifications

The Audio Device Reader used is Microphone (Realtek High Definition Audio) with the Sample Rate of 44100 Hz, the Buffer size that is used is 64, Delay Length is 1000 with the gain of 0.8, 0.6 and 0.4. The list of signs assigned are ++++. Speaker/Headphone (Realtek High Definition Audio) is used as Audio Device Writer.

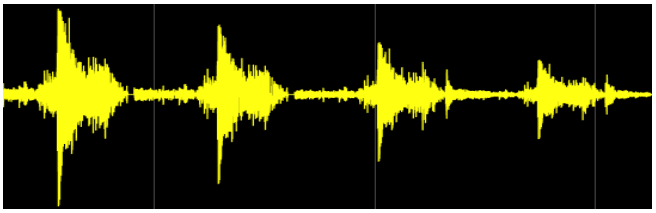

Figure 2- Waveform of multiple echo

B. Delay

Dealy is the repetation of original sound after certain time interval without any attenuation. Buffer is used to temperory store the real-time input signal.

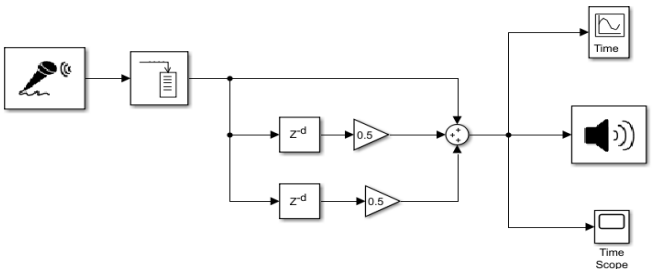

Fig 3 - Simulink model of delay

C. Blocks description

The Audio Device Reader used is Microphone (Realtek High Definition Audio) .Sample Rate is 44100 Hz and the Buffer size that is used is 64, Delay Length is 1000 with the Gain of 0.5. The list of signs assigned are -+++. Speaker/Headphone (Realtek High Definition Audio) is used as Audio Device Writer.

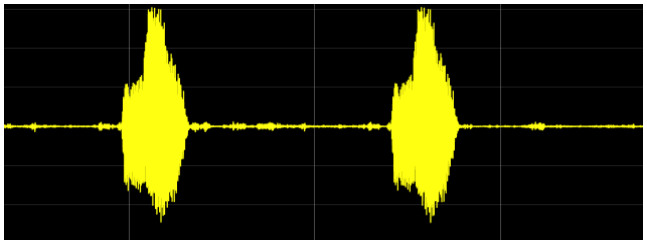

Fig 4- Waveform of delay

D. Reverb

Reverbation is the super-imposition of multiple echos and the sound signal remains in the space even after the original sound decays. Reverb not only occurs in indoor spaces but also takes place in the outdoor environment wherever reflection is possible.

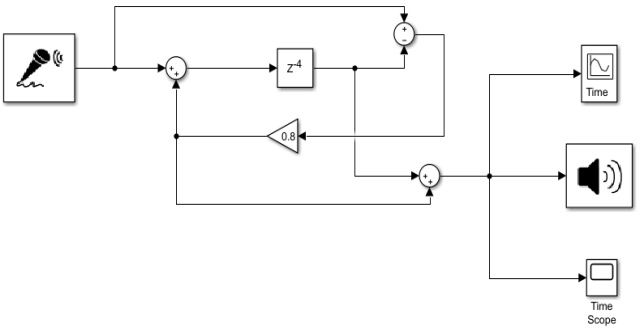

Fig 5- Simulink model of reverb

E. *Blocks Specification*

The Audio Device Reader used is Device-Microphone (Realtek High Definition Audio) with the Sample Rate of 44100 Hz, Delay Length is 4 with the Gain of 0.8. The list of signs assigned are 1++, 1+-. Speaker/Headphone (Realtek High Definition Audio) is used as Audio Device Writer.

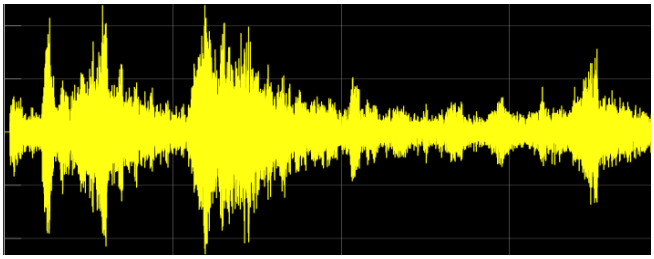

Fig 6- Waveform of reverb

F. *Stereo*

Stereo is the multi-directional effect which creates the illusion that the sound is coming from more that one source and the sound which is audible in one speaker is reproduced in another speaker with certain delay.

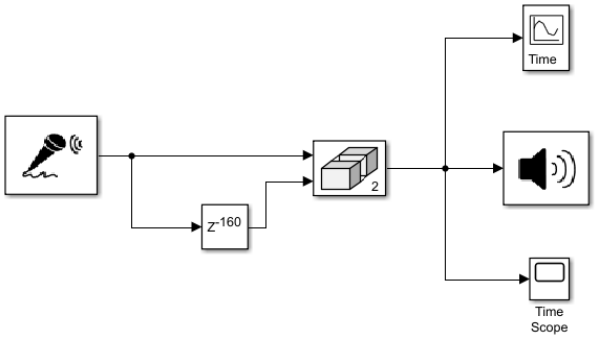

Fig 7- Simulink model of stereo

G. *Blocks Specification*

The Audio Device Reader used is Device-Microphone (Realtek High Definition Audio) with the Sample Rate of 44100 Hz, Delay Length is 160 with number of inputs in Matrix Concatenate as 2. Speaker/Headphone (Realtek High Definition Audio) is used as Audio Device Writer.

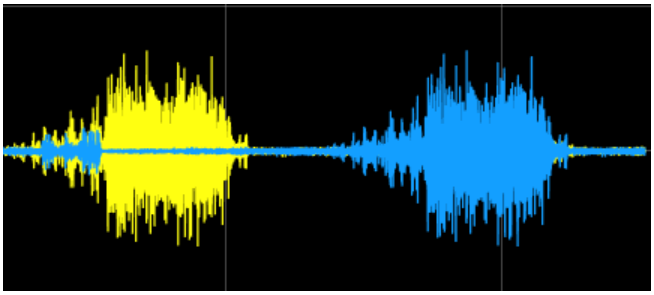

Fig 8- Waveform of stereo

H. *Chorus*

Chorus effect is the convergence of the sound from multiple sources having similar pitches produced at the same time. The sound coming from multiple instruments can be replaced by a single instrument using Chorus effect.

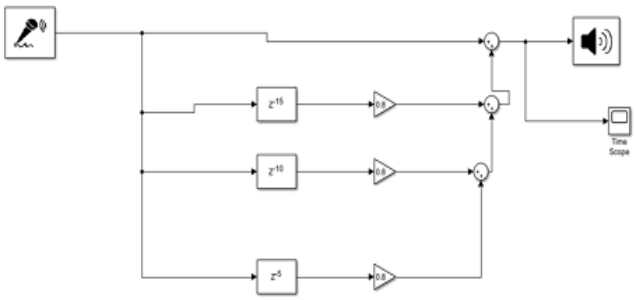

Fig 9- Simulink model of Chorus

I. *Blocks Specificaton*

The Audio Device Reader used is Device-Microphone (Realtek High Definition Audio) with the Sample Rate of 44100 Hz, Delay Lengths are 15, 10, 5 with the Gain of 0.8. Speaker/Headphone (Realtek High Definition Audio) is used as Audio Device Writer.

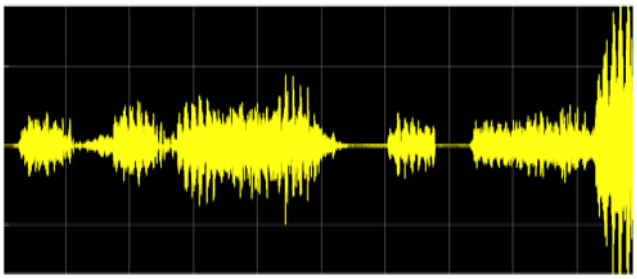

Fig 10- Waveform of Chorus

Also, some more effects like Simple Echo, Distortion, Phasor and Flanger has been implemented in Simulink model and the output is obtained. Simple echo is the reflection of the sound only once, Distortion is the modification of the original shape or other characteristics of something. In the frequency spectrum, the series of crusts and troughs produces the Phasor effect and Flanger effect is created by combinig two similar signals.

IV. ADVANTAGES

The main advantage of this project is that it can be implemented in real-time during the live performances by taking audio signal from the Guitar and by producing different effects and hence this replaces the pre-recorded sound clip. Since this project is implemented in the digital domain, this has less complications. This project focuses on converting all types of audio into the particular effect.

V. LIMITATIONS

1. It is applicable only for Acoustic Guitar.
2. It takes only the signals ranging between 20 to 20k which can be clearly audible.
3. There may be chances of software compatibility issues (host, drives and plug-ins).
4. Since we are bringing our output signal in digital audio it may be too clinical/cold.

VI. CONCLUSION

In this project real time audio effects for acoustic guitar are enhanced and obtained with the knowledge of Simulink. This project overcomes the digital audio effects over analog and also it replaces the recorded audio effects that are used in music field.Thus it helps to create a real time digital audio effects which can be used in live performances and also for pre-recorded audio.This effects can be future modified and used in many fields like video games,musicplayers,movies etc.

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