Digital Modeling/Implementation of Valve Amplifiers

Statement of Problem

Cody Frye & Mitchell Gould

I. Motivation

Since the 1960's, vacuum tube amplifiers have been widely used in concerts and live music settings. They provide class sound effects and warm signature tones. They come in a broad variety of shapes and sizes. Every model has its own signature tone that musicians specifically seek out. When it plays loudly, the sound of vacuum tube amplifier arguably presents much better than the sound from a solid state amplifier. Unfortunately vacuum tubes are large components that overheat often. In addition, tubes have a short life span and they can burn out at any time. Sometimes this even can cause damage to the transformer and other components. Once they burn out, they often need to be replaced quickly. The downside of using a tube amplifier is not only the overheating and aging problems. These pieces of equipment can be too heavy to be moved with ease. This problem is compounded by the fact that most bands have multiple guitar and bass players. Most of them need their own amplifier. The cost of transporting and maintaining these tube amplifiers can be a burden on the musicians and music event planner. Musicians are constantly in need of gear that not only is lightweight and cost effective, but gives them the ability to have any tube amplifier at their disposal for the wide range of gigs and sessions.

II. Goals

This project aims to design a digital emulation of an analog valve amplifier with the non-linear characteristics being reconfigurable. An audio processing algorithm is to be utilized to automate the process of approximating the nonlinear characteristics of audio amplifiers. The goals for this project are listed as followed:

- Decompose audio signals into frequency bins
- Generate the lookup tables for each frequency bin
- Automate the process of obtaining the lookup tables to approximate the non-linear characteristics of audio amplifiers
- Address the problem of modulated distortion
- Implement the algorithm in real-time on an embedded system
- Utilize low cost embedded platform

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System Block Diagrams

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Signaturing Process

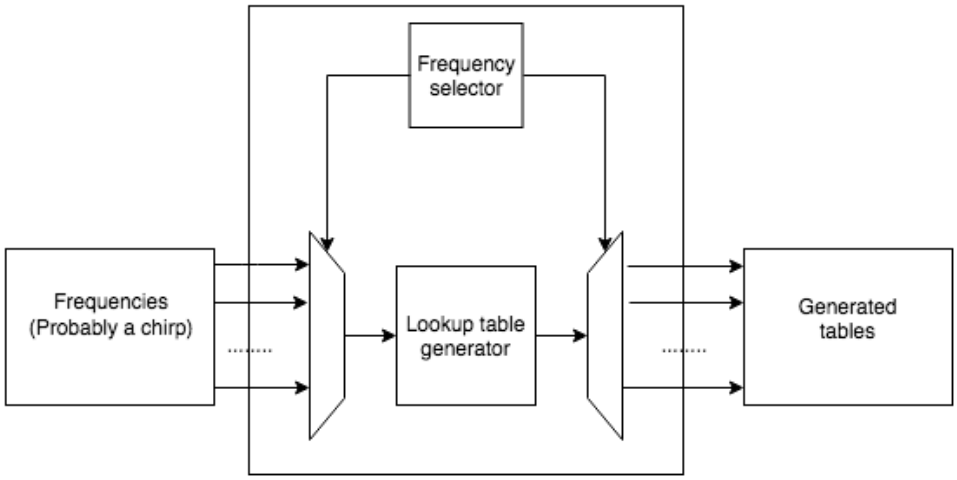

Fig.1 Signature Process Diagram

Real-Time Emulation

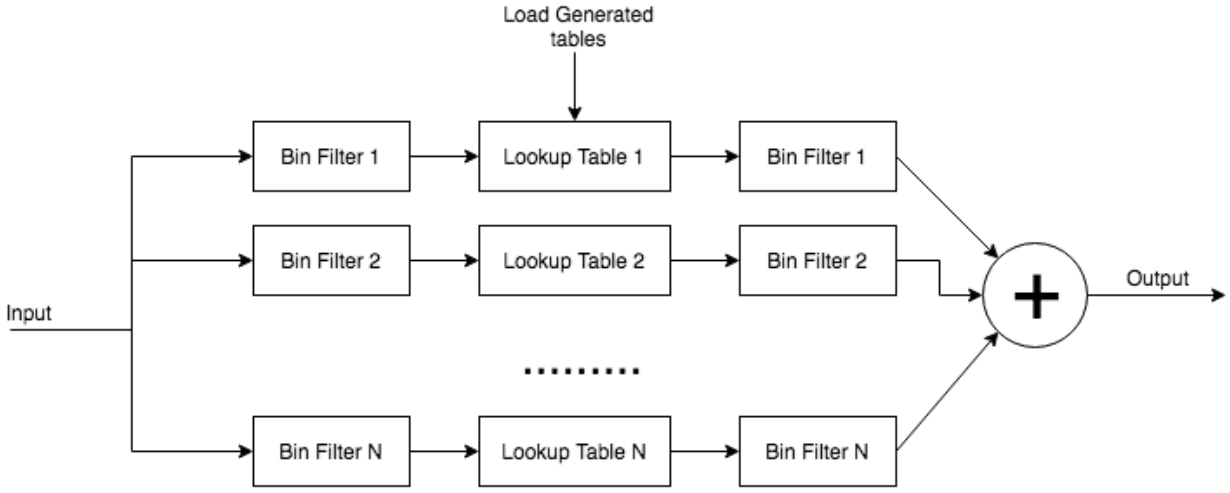

Fig. 2 Emulation in real-time processing

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Functional Description

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III. Block Diagram Function Descriptions

Figure 1 describes the process of obtaining the nonlinear characteristics (signaturing) of the amplifier. It includes:

1. Lookup Table Generator:
    - An algorithm to convert the input signal data and the output amplified/distorted data into a lookup table.

2. Frequency Selector:
    - Function to select which frequency range to be read at the lookup table generator. It sweeps to achieve multiple lookup tables across multiple frequency ranges

Figure 2 describes how the algorithm is implemented in real-time on an embedded platform. It includes:

1. Load Generated Tables:
    - Function that loads the generated lookup table to it's respected frequency bin.

2. Bin Filters:
    - FIR filters are designed to allow only a specific set of frequencies to pass into the bin.