

Project 3: The Virtual Electric Guitar

Math 5740, Spring 2003

The history of the modern electric guitar is interesting. Development of early electric guitars was driven by the need for instruments which could be heard clearly in noisy clubs, large venues, and in the midst of large bands. Acoustic guitars simply did not produce enough acoustic power to perform well in these situations. With the advent of electronic amplifiers, it became possible to greatly magnify the loudness of an individual instrument, but generally at the same time the sound of the instrument was significantly altered. The solidbody electric guitar in the basic configuration with which we are now familiar evolved mostly in the late 1940s through 1950s, along with vacuum tube amplifiers, as a distinctly new instrument with its own unique sound.

Interestingly, even though technology has since become much more sophisticated, many musicians still prefer 1950s-style amplifiers and guitars. Unfortunately there are a lot of practical problems with these instruments (mainly the amplifiers), including high cost, poor reliability, poor stability, and high noise. These problems led to substantial efforts by the musical instruments industry to achieve the sound qualities of 1950s-style instruments with modern technology.

Until approximately five years ago, most of these efforts were widely shunned by musicians. At that point, several manufacturers succeeded in developing *digital* signal processors which *mathematically model* the most highly coveted vacuum tube amplifiers of the past, with such high accuracy and low cost that they quickly became a huge commercial success. Many of these manufacturers have continued their modeling efforts with the aim of reproducing the sounds of more and more rare, esoteric, or high cost equipment, all with mathematical algorithms. The ultimate end of all this activity would be a complete electric guitar which exists only as a mathematical model. Producing such a model is the goal of this project. As a side note, at least one manufacturer has within the past year put an instrument on the market which consists of a very inexpensive guitar, coupled with a box capable of modeling the sounds of many other expensive guitars. This is “almost” a complete virtual guitar.

An electric guitar is a complicated device, consisting of many interacting mechanical and electrical systems. Nevertheless, we can break it down into several basic blocks:

1. Strings,
2. Pickups,
3. Neck and body,
4. Amplifier,
5. Speaker and recording microphone.

One group will be assigned to each of these blocks. It will be absolutely necessary for each group to communicate with, and to help out, other groups. Each person is working for the success of the entire project, not just their particular group.

You will have access to an electric guitar, and a commercial amplifier modeling box. The goal of the guitar modeling (groups 1, 2, and 3) is to model the particular electric guitar and pickups with which you are provided. The goal of the amplifier modeling (groups 4 and 5) is to model a 1959 Fender Bassman amplifier. This amp is modeled by the “TWEED BLUES” setting on the modeling box.

Obviously with our limited time and resources, we will not be able to produce a polished model which runs in real time. The goal of the project will be, as always, to do the best we can in the time available. As you read through guitar-related literature, you will notice a lot of strange terminology and strong opinions describing subtle differences between instruments, amplifiers, and tones. Don't be frightened. Remember, you are modeling a *physical* system which can definitely be understood and analyzed.

Of course, the biggest influence on the sounds produced by any given guitar and amplifier is the player. Modeling the player is beyond the scope of the project.