Using Impulse Response Technology to Recreate the Sonic Characteristics of Analog Microphone Preamps and Acoustic Spaces

By
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Abstract:

The study of impulse response technology allows audio engineers to attempt to recreate the tonal characteristics of a certain device. The purpose of this project was to recreate a sonic representation of analog microphone pre amplifiers and acoustic spaces through the use of impulse response technology. By creating these impulses, the student will attain the sonic characteristics of professional grade audio devices with impulse files, be able to enhance his recording and mixing capabilities, and create new and innovative sounds using these audio files.

Introduction:

An impulse response refers to the reaction of any dynamic system in response to some kind of input. Study of impulse response technology has been prevalent within the audio world for the last decade. Impulse response technology has been used for several different purposes. It has been discovered that with this technology one can essentially recreate an acoustic space, or device using certain techniques. By sending amplitude of signal through a certain device you can record its time and tonal based characteristics, therefore giving you a representation of the signal through an impulse response. This impulse response can then be added on to any audio track within a digital audio workstation by the use of an audio plug-in (Figure 3).

The study of impulse response technology has benefited audio engineers and students everywhere. Students now have the capability of capturing any acoustic environment and digital reverb device they want. Studies correlating impulse response technology and analog microphone preamplifiers are extremely limited. Certain techniques allow you to recreate the sonic characteristics of digital reverb devices and the same techniques can be used on analog microphone preamplifiers. Two techniques that allow you to accomplish this are the Time-Pulse Technique and the Frequency Sine Sweep Technique. The Frequency Sine Sweep Technique is a generated time based sine sweep of the human aural spectrum (20Hz-20kHz), which documents a representation of the device via impulse response. The Time-Pulse Technique is a short waveform spike, lasting a few milliseconds, that is played through the specific piece of outboard gear documenting a representation of this specific device via impulse response. These two techniques allow for two different styles of documentation and representation to provide a comparison for the best results possible.

Technique/Listening:

Frequency Sine Sweep Technique:

Generating a time based sine sweep allowed for the documentation of the signal to noise ratio over a selected length of time, ten seconds. Patching the audio output into the input of the preamp supplied the preamp with enough signal to properly document the preamp signal. Taking the output of the preamp and patching it back into the input of the audio interface connected to your computer resulted in the recording of the preamp signal. Fuzz Measure Pro is an audio program that allows you to take a frequency specific sine sweep (20Hz to 20kHz), send it through a device, and deconvolve the returning signal from the preamp into an approximated impulse response of the analog preamp.

Time-Pulse Technique:

Creating a pulse of amplitude with a length of milliseconds allowed for a suitable signal to noise ratio, which can capture the transients over time of each preamp. Sending this pulse of amplitude, through a Digital Audio Workstation (DAW), into the input of the preamp resulted in the impulse response of that preamp. Taking the output of the preamp and patching it into the input of the Digital Audio Workstation resulted in the recording and documentation of signal and harmonic distortion through the preamp. This process allowed for accurate analysis of the sonic qualities of the preamp.

To get an accurate representation of each preamp signal so that a comparison between the impulse and preamp could be made, the original recorded signal had to be sent through each specific preamp to get the tonal characteristics associated with each preamp. Taking the output of the original signal recorded and patching it through the designated preamplifier resulted in the signal with the per amp characteristics. This process was repeated for all of the preamps giving us an appropriate representation to compare the impulse response with.

Figure 1 illustrates the patching of the output of the DAW into the input of the preamp and the output of the preamp back into the DAW.

The next step was to figure out how we were going to compare our impulse signal against the original signal of the preamp. Recording electric guitar, acoustic guitar, and drums allowed for a wide variety of timbre and frequencies to compare the original signal of the preamp to the impulse response signal of the same preamp. These instruments were recorded using a measurement microphone (Beyer Dynamics MM1) through the cleanest microphone preamp available (Grace Designs m501).

Figure 2 illustrates the recording of the drums using the Beyer Dynamic MMI microphone to capture the natural sound of the drums. (Same process for acoustic and electric guitars)

Taking the recorded signal and patching it through each of the preamps created an accurate sonic representation of each preamp. Attaching an impulse response plug-in on the original recorded signal created a comparable representation of each preamp. The digital audio workstation (DAW) logic pro 9 allowed for the comparison of the signal of the impulse response and the original preamp. By creating two tracks the appropriate audio files were imported and compared. The first track was the original recorded audio file with the impulse response plug in on the track. The second track was the signal recorded through the specific preamp. This allowed for a more accurate A/B comparison between the two different signals. This process was then done for all of the preamps.

Figure 3 illustrates the comparison between the original recorded track of each preamp against the base track recorded with the Impulse response plug-in attached to it.

Results

The frequency sine sweep technique to find the impulse response is ideal for recreating digital reverb devices and acoustical spaces. After completing several tests, this method of sending a frequency sine sweep through a preamp showed no fluctuation between the different preamps. Figure 4 illustrates the preamps frequency response curves versus the magnitude level (dB) using the sine sweep method. There is no variation between signals, thus it provided no variation of tonal characteristics between preamps and did not display the harmonic qualities associated with each specific preamp. This test proved inconclusive for attempting to recreate an impulse model of the preamp.

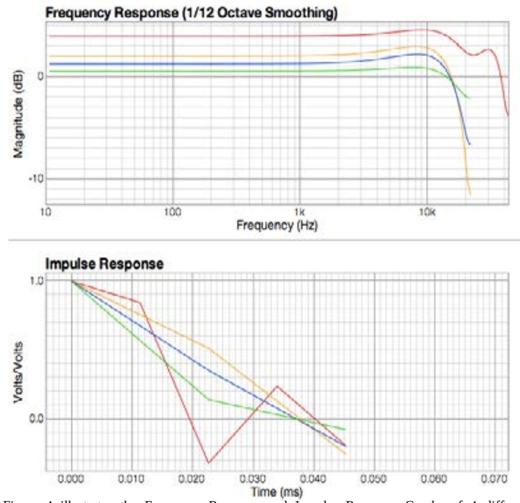

Figure 4 illustrates the Frequency Response and Impulse Response Graphs of 4 different microphone pre-amplifiers using the Sine Sweep Technique. Green: Grace Designs m501, Orange: Tonealux MP5A, Blue: A-Designs P-1, Red: Vintech Audio 573

After completing several tests using the time-pulse method, varying frequency response graphs were present. Figure 5 illustrates the preamps frequency response curve versus the magnitude level (dB) from the time pulse approach. Each of the curves has variations very similar to the harmonic characteristics of the specific preamp. The tonal qualities of each preamp fluctuate due to different materials presented within each device and the time-pulse method provided accurate representation of tonal qualities mixed with harmonic distortion to sufficiently recreate a precise sonic representation of the preamp.

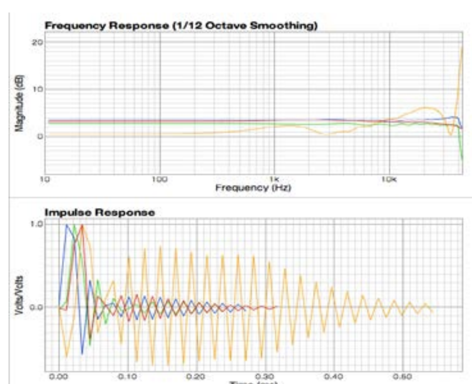

Figure 5 Illustrates the Frequency Response and Impulse Response Graphs of 4 different microphone pre-amplifiers using the Time-Pulse Technique. Green: Grace Designs m501, Orange: Tonelux MP5A, Blue: A-Designs P-1, Red: Vintech Audio 573

Using multiple instruments (electric guitar, acoustic guitar and drums) with various timbres, a comparison between the base signal and the impulse response signal was evident. This first indication heard from the impulses was when the impulse response (IR) plug-in was inserted onto the base audio track show in figure 3. A distinct change in tone and harmonic quality was evident when the IR was added to the base track. Listeners could differentiate when the impulse was inserted onto the track.

The comparisons between each of the original preamp signals and the impulse response signals maintained similar tonal characteristics and harmonic qualities. The impulse response signal was not an exact recreation of the original preamp signal, but a clear similarity in tonal quality and sonic characteristics was present within both of the tracks. For example, the A-Designs P-1 has a distinctive bass tone, which the impulse response also maintained. Although graphs may not show this bass tone, there is still an audible distinction that is similar between the two signals.

Note: All findings are subjective, based on individual listeners and their capacity to hear varying frequencies and tones.

Conclusion/Discussion:

Impulse response technology has become exceedingly popular over the last decade. It has been used to recreate digital reverb devices, and acoustical spaces. The study of impulse response technology for the use of recreating the sonic properties of analog microphone preamps is a rare field of study. Using two popular impulse response techniques (frequency sine sweep technique and the time-pulse technique) a comparison between the original preamp signal and the impulse response signal was concluded.

The frequency sweep technique proved to be inconclusive when determining the impulse response of the various preamps. Figure 4 shows the frequency response curve versus the magnitude level (dB) of several different preamps with distinctive tonal characteristics. The graph shows no fluctuation between the varying preamps. No audible difference could be perceived when listening to an A/B comparison.

After multiple studies on the time-pulse technique the results proved to vary from preamp to preamp, showing the distinctive tonal characteristics and harmonic qualities within the frequency graph curve (Figure 5). When listening to an A/B comparison a plausible comparison between the original preamp signal and the impulse response signal was concluded. Several of the tonal qualities that are distinctive to certain preamps were audible within the impulse response.

The impulse response signal was not an exact recreation of the analog microphone preamp, but most of the tonal characteristics and harmonic qualities that are distinctive between each of the preamps were present within the impulse response. The time-pulse technique of capturing the impulse response proved to be a feasible way to sonically represent each preamp to improve the quality of recording and enhance the mixing capability of students who are not fortunate enough to purchase professional grade equipment. Although only four preamplifiers results are displayed, a total of fourteen preamplifiers and eight acoustical spaces were recorded, providing a wide variety of tones and spaces for students to experiment with when recording at home. The goal was to develop a viable way to recreate the tonal characteristics of analog preamplifiers and acoustical spaces to develop the education possibilities of the students within the Music and Sound Recording program at the University of New Haven. With more research, and as technology develops, complete digital recreation on analog microphone Pre Amplifiers is a realistic possibility.

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Kevin Boettger is currently a senior at the University of New Haven expecting to graduate in May 2013 with a B.S. in Music and Sound Recording with a Global Studies Minor. Kevin grew up in Middletown, NJ where his family first opened him up to the world of audio. After he graduates Kevin hopes to continue working in the audio field, and would like to become an audio engineer. Eventually he would like to start his own business designing analog gear and digital plug-ins. This research has opened Kevin's mind to the endless possibilities within the audio field, and that with hard work, creativity and passion, a dream will become reality.