The Cajón and its Response to Damping

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1 Introduction

The cajón is a defined, quite literally as a "box with a hole in it" or "crate". It is an instrument hailing from Peru which is depicted in Figure 1.

A cajón is typically made of sheets of plywood but the thickness varies based on the side. In general, 5 of the six sides are made with plywood that is 1.3 to 1.9 cm

Figure 1: A standard cajón as seen from the front.

thick. The striking surface, referred to as the tapa, is usually thinner. On the surface directly opposite the tapa a sound hole is cut out, this can be seen in Figure 2. On the inside of the cajón against the tapa, drum snares are usually attached to give produce a buzz or rattle when the surface is attacked. These snares are depicted in Figure 3.

A player of the cajón would sit atop the box and strike the tapa, often tilting the entire box at an angle while playing.

2 Experiment Description

The experiment I chose to run on the cajón was to investigate the harmonic content and frequency response of the cajón under different damping conditions. Upon doing research into common damping techniques, I decided that the method I would apply would be to damp the cajón using towels. The procedure for the experiment was as

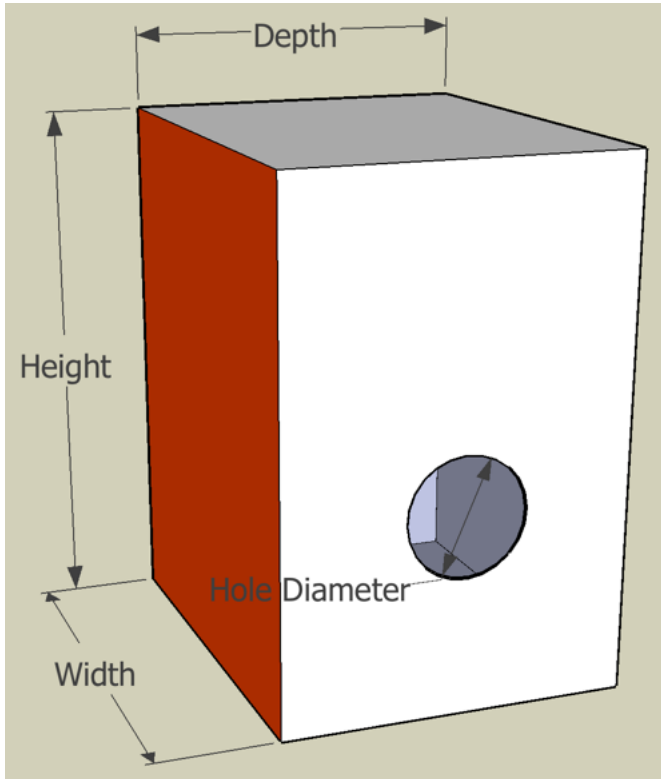

Figure 2: A standard cajón as seen the rear, showing off the sound hole.

follows.

1. Set up cajón in a playable position in a quiet room.
2. Put a microphone on a stand near the back of the cajón near the sound hole.
3. Record the audio off the cajón while attacking the front surface repeatedly in a similar fashion aiming for a bass-y tone.
4. Save the audio track
5. Repeat the previous steps but progressively add towels to the inside of the cajón. Record audio first with 1 towel, then 2, 3, etc. until no more comfortably fit.

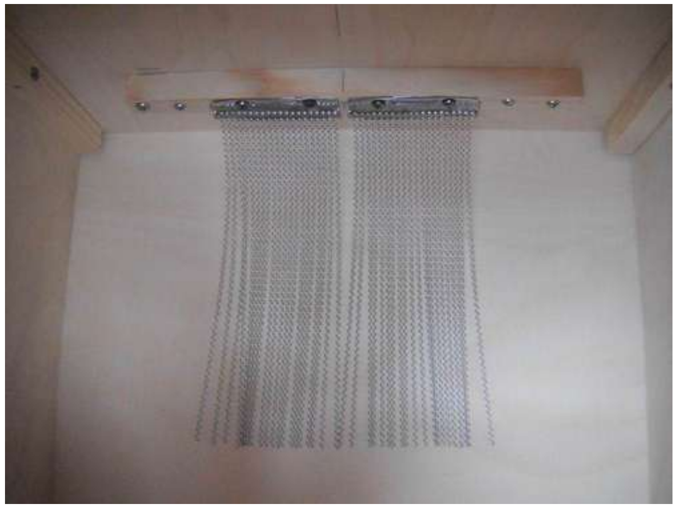

Figure 3: A depiction of the inside of a cajón, showing the snares positioned against the tapa – the striking surface.

After collecting all the data, I piped the audio into the `wav_analysis` Matlab program. For all the samples (i.e. coming from an empty cajón all the way through a cajón filled with towels) I took the waterfall plots from each recording (which was many successive attacks) as well as found the harmonic content and displayed the power spectral density. I also went through and isolated a single, specific attack for each recording and took an image of the time-domain waveform for that specific attack. Below, along with a description of what I interpreted to be the results are the images representing this data.

3 Results

Waterfall Plots

The waterfall plots were interesting to see but not very telling in terms of differentiating between a full and empty cajón. The differences were not clearly discernible and therefore the waterfall plots did not provide much insight as to what specifically was happening under damping conditions. For brevity, I only included the waterfall plots of the full and empty cajón, not including the intermediary samples (which had 1 and 2 towels, respectively). These can be seen in Figures 4 and 5.

Power Spectral Density

Slightly more telling but still not very conclusive were the power spectral density plots. Across all the recordings the harmonics looked very similar, although the quality of some of the crests in the graph certainly looked different in the full cajón as opposed to the empty one. There's also some slight attenuation in the lower frequencies, but it is not significant enough to warrant further discussion. These can be seen in Figures 6, 7, 8 and 9.

Time-domain Waveform

The most interesting quantitative results were found in the time-domain waveforms processes from a single attack. These can be seen in Figures 10, 11, 12 and

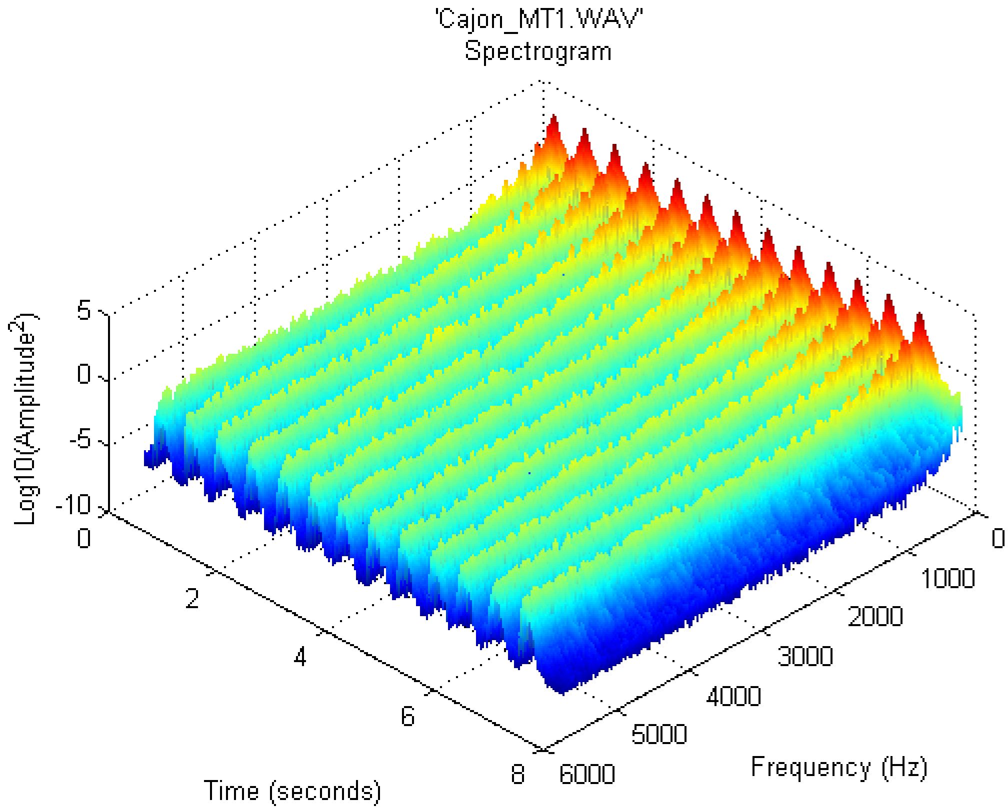

Figure 4: Waterfall plot from sound sample with an empty cajón

13. In these charts we can clearly see a difference in the decay time, i.e. the time it takes for the attack to diminish – in the 4 samples. The sustain of the attack is clearly lessened between trials. Furthermore, it does not appear linear. The time-domain waveform data for the attack from the full demonstrates a much faster decay than even the nearly full cajón indicating that the effects seemingly linear properties become super linear when the cajón is nearly full. This was the most interesting and clearly made observations from the experiment and the most relevant as well.

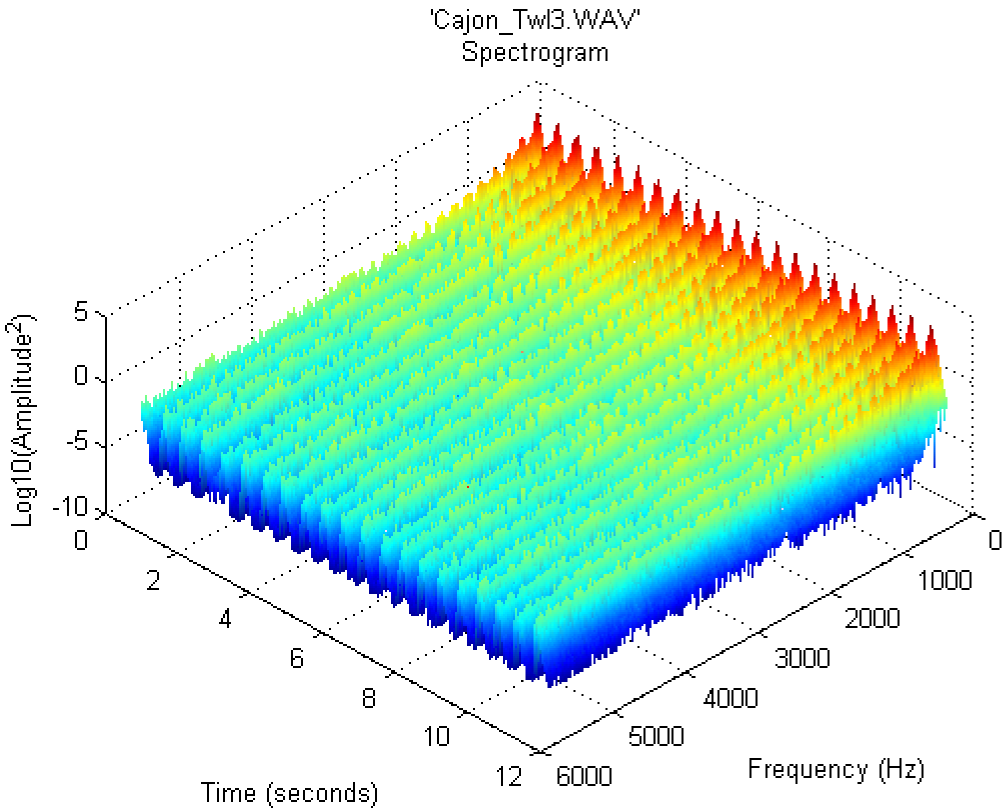

Figure 5: Waterfall plot from sound sample with an empty cajón

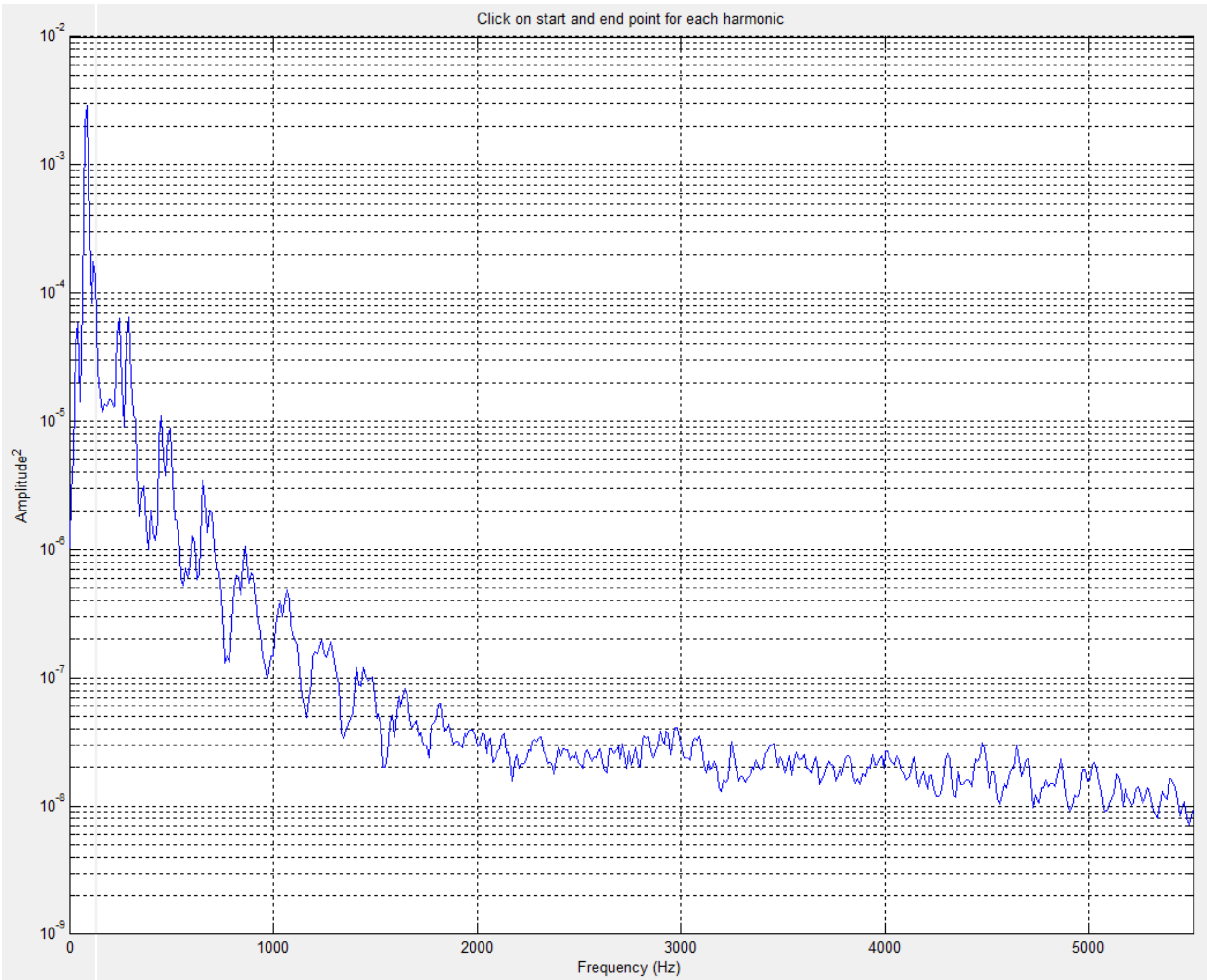

Figure 6: Power spectral density from a cajón recording with no towels

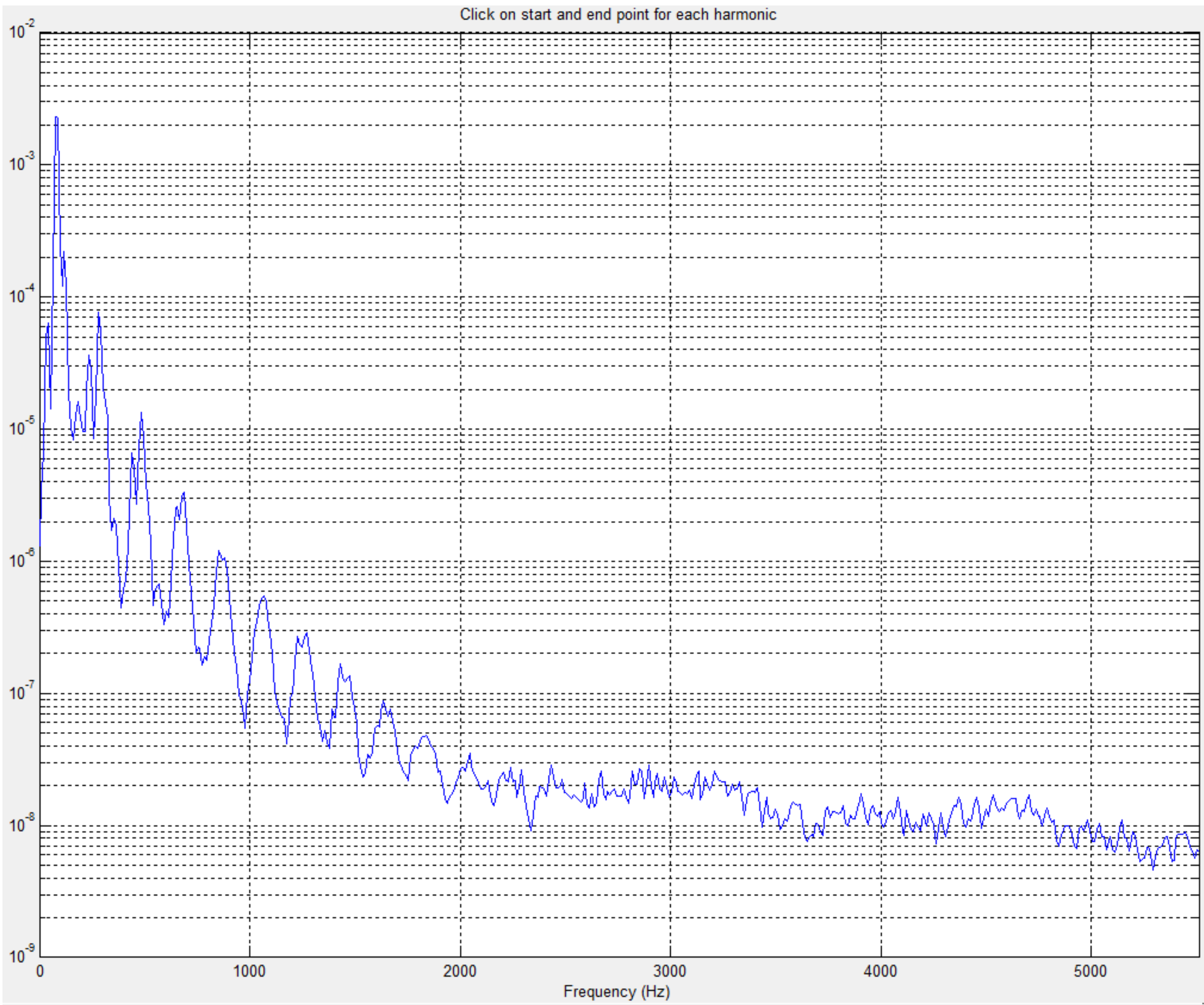

Figure 7: Power spectral density from a cajón recording with 1 towel

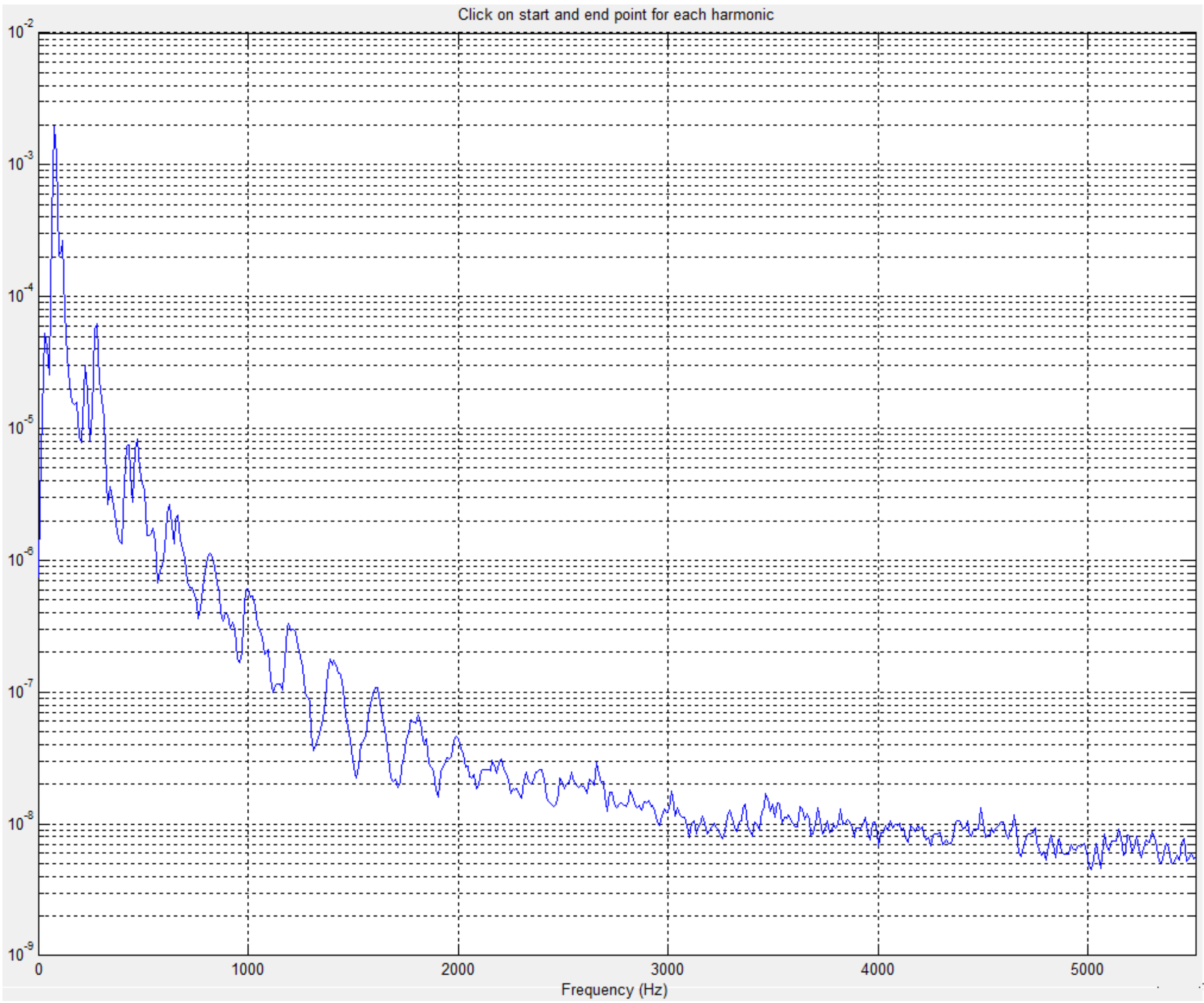

Figure 8: Power spectral density from a cajón recording with 2 towels

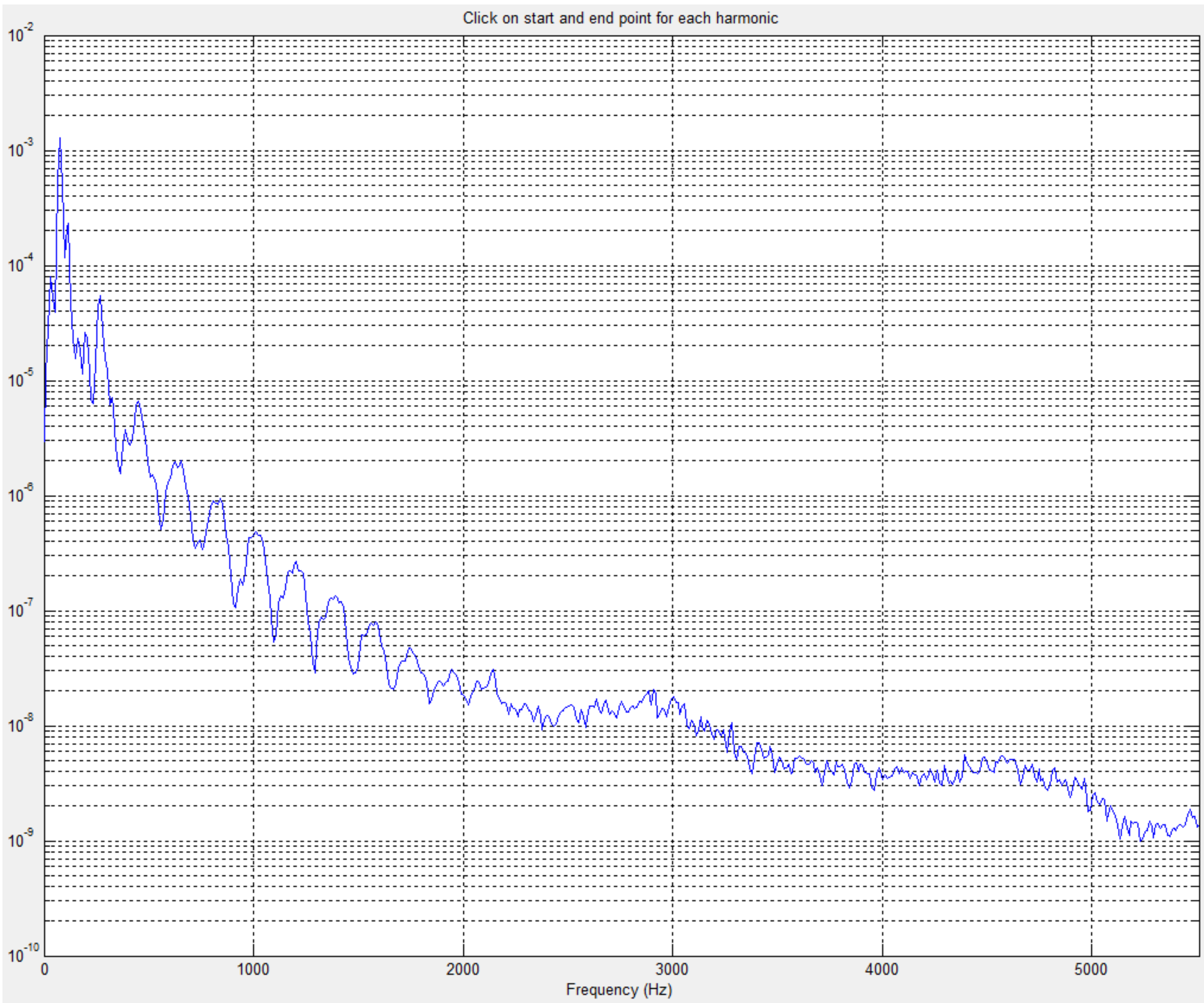

Figure 9: Power spectral density from a cajón recording with 3 towels

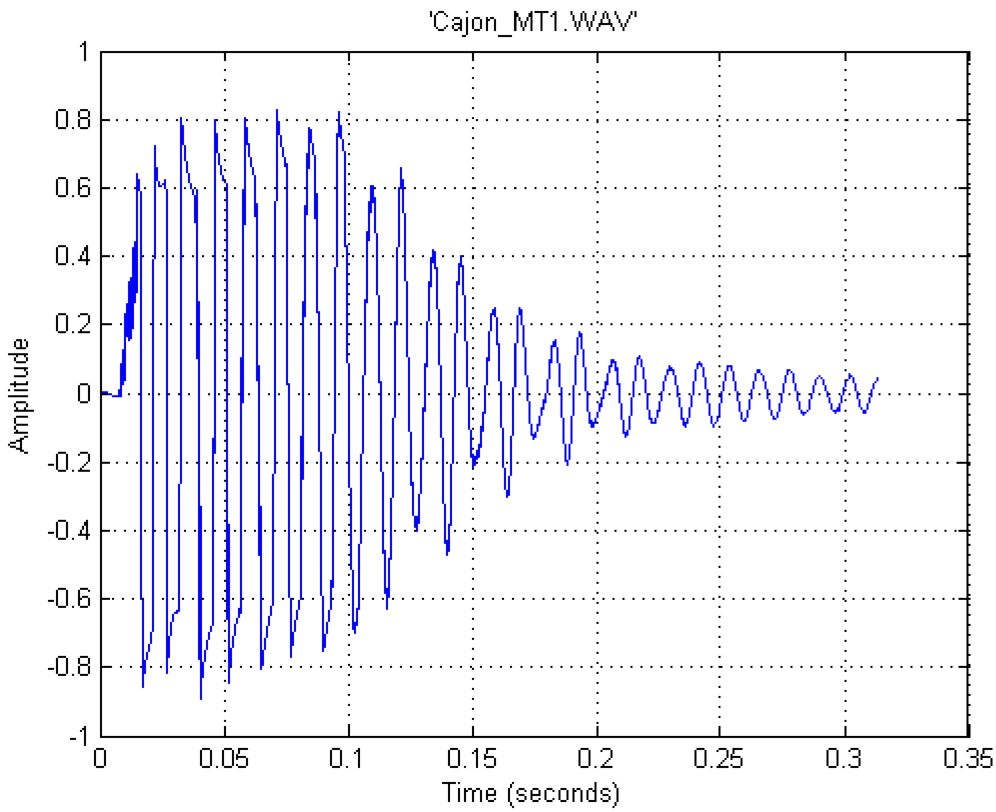

Figure 10: Time-domain waveform from a cajón recording with no towels

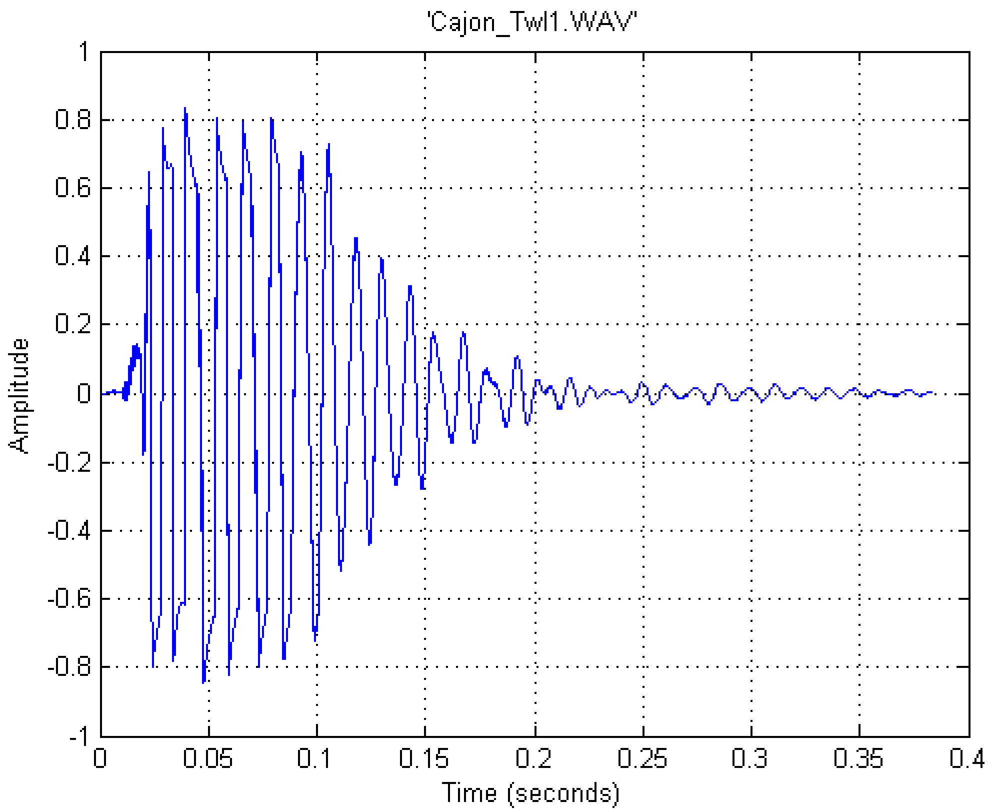

Figure 11: Time-domain waveform from a cajón recording with 1 towel

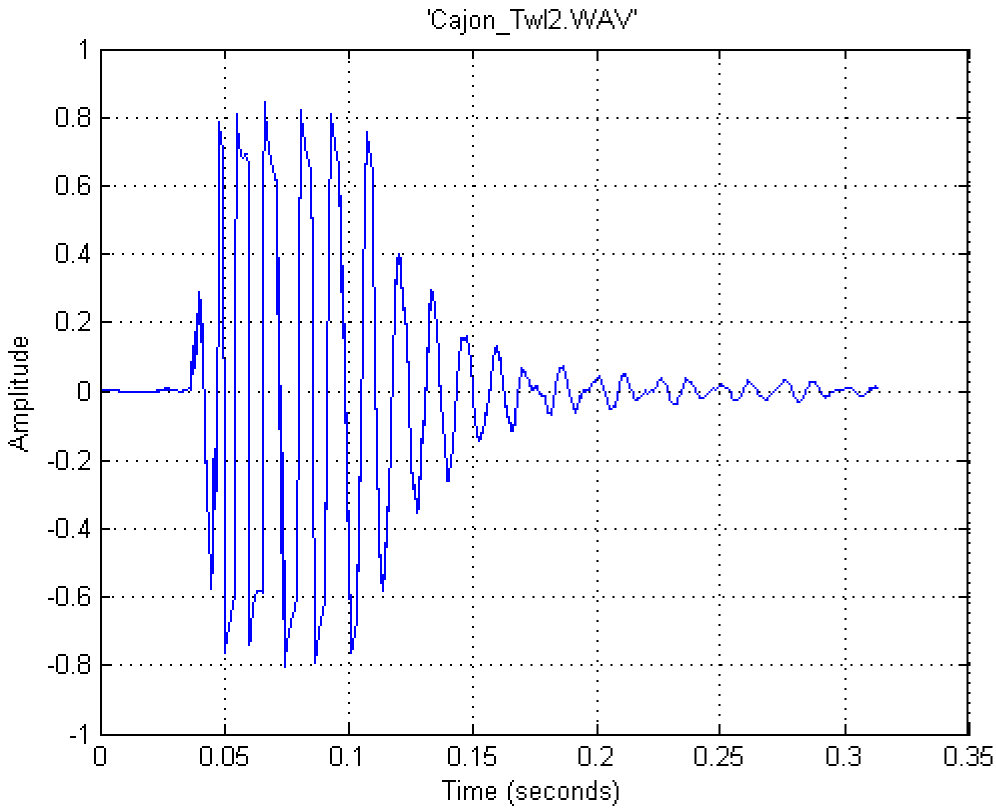

Figure 12: Time-domain waveform from a cajón recording with 2 towels

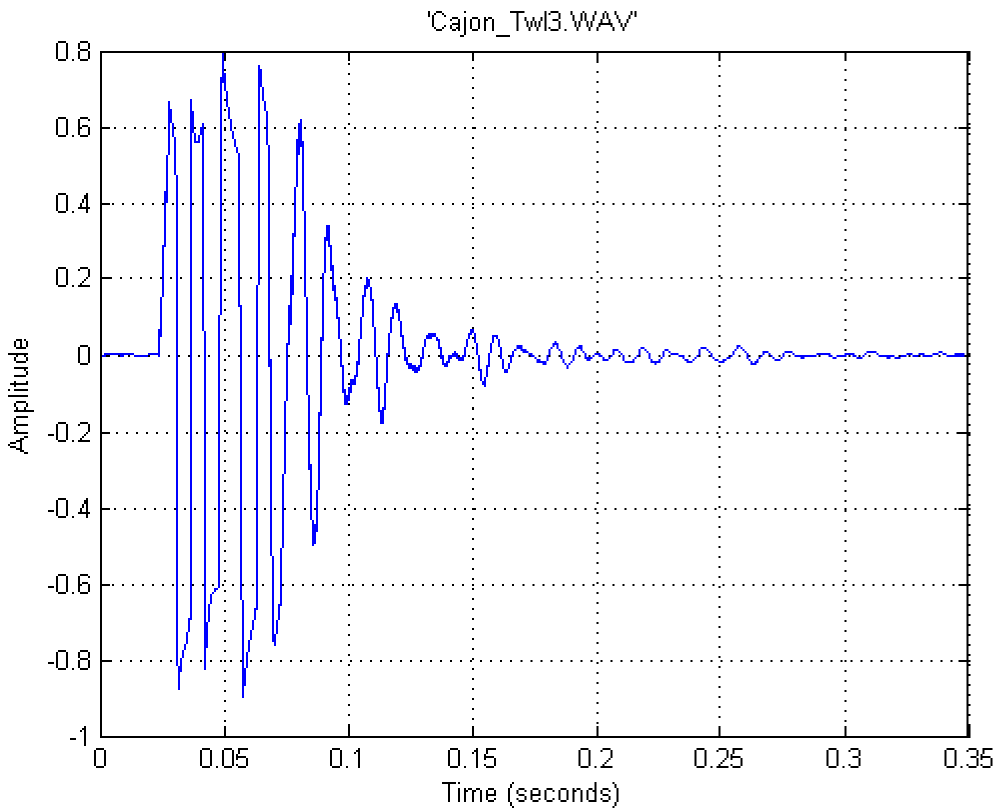

Figure 13: Time-domain waveform from a cajón recording with 3 towels