<u>Bass Guitar Analysis</u>

Tom Rocko – Spring 2014

For my project I recorded and compared the sounds coming off three different bass guitars. Last semester I learned how when an instrument or singer play a note, they are not just producing the fundamental frequency. Depending on the instrument, there are different harmonics being played along with the fundamental. My goal was to find these harmonics and compare them between the instruments. The two guitars I brought in were my Fender Squire P-Bass (left) and a friend's Fender Acoustic GB41-SCE bass (right). I assumed that the acoustic bass would have a broader range of harmonics since it is an acoustic instrument and it costs about $400 compared to the $100-$150 Squire.

Procedure

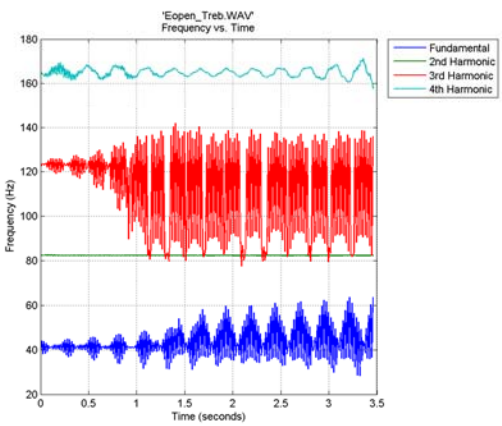
In order to perform some analysis on the sounds, we first recorded several different notes from both the Squire and acoustic bass. Professor Errede helped me record them and input the sounds into the computer. We then ran the sounds through the wav_analysis.m Matlab script. Along with looking at the open strings of both the Squire and acoustic, I pulled some data of a 76' Fender P-bass to use as a benchmark for a good instrument.

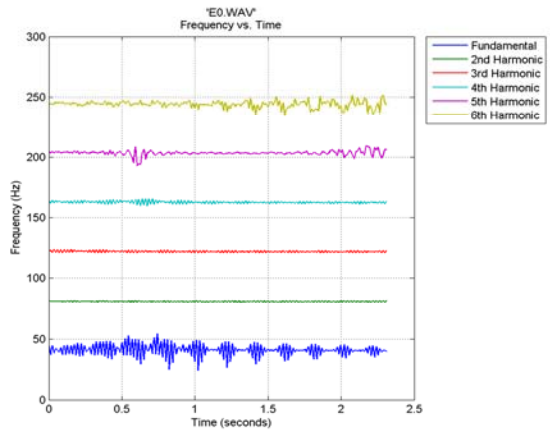
For comparing the amplitudes of the harmonics between the new and old strings, I recorded the sounds directly into my computer and analyzed them using a Matlab script I found online.

Frequency vs. Time

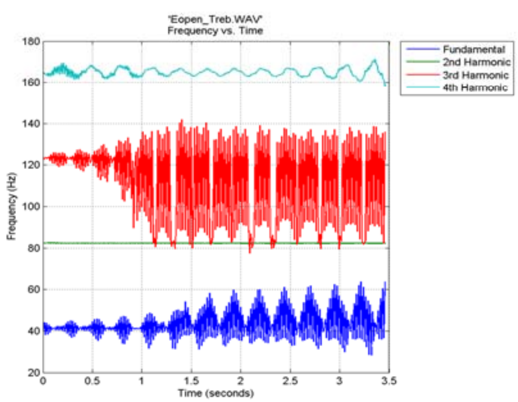
The graphs below compared the Frequency vs. Time of each measured partial between the Squire and P-Bass, or the Squire and acoustic.

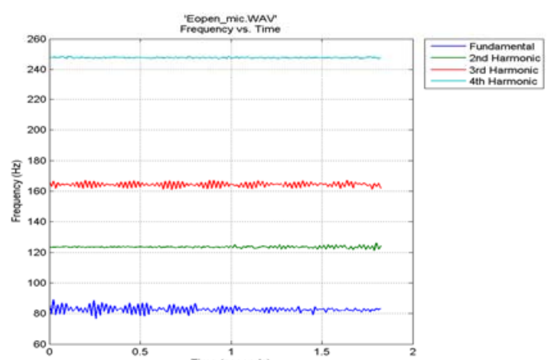
Frequency vs. Time E (Pbass)





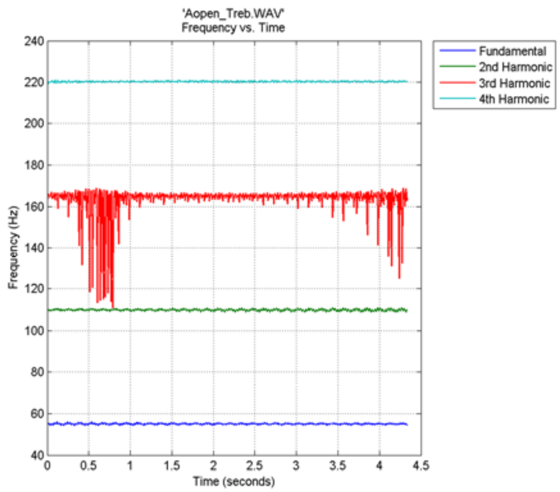
Frequency vs. Time E (Acoustic)

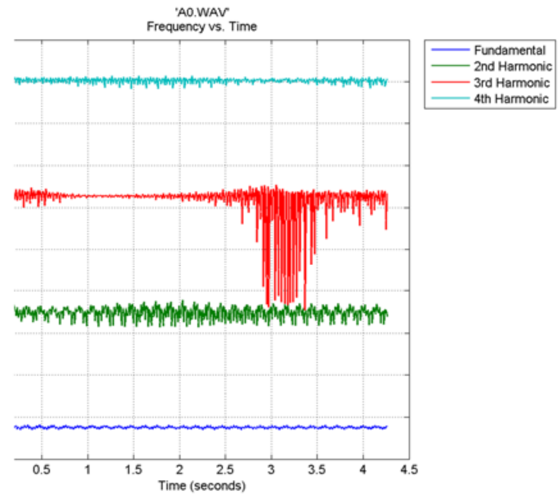




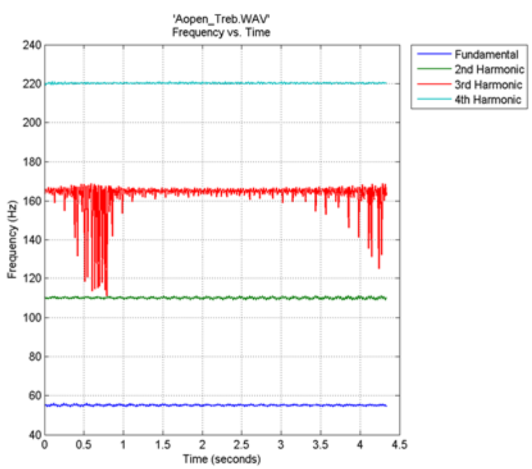
For the open E, the Squire's frequencies for the first and third harmonic varied greatly over time while both the P-Bass and acoustic stayed relatively flat.

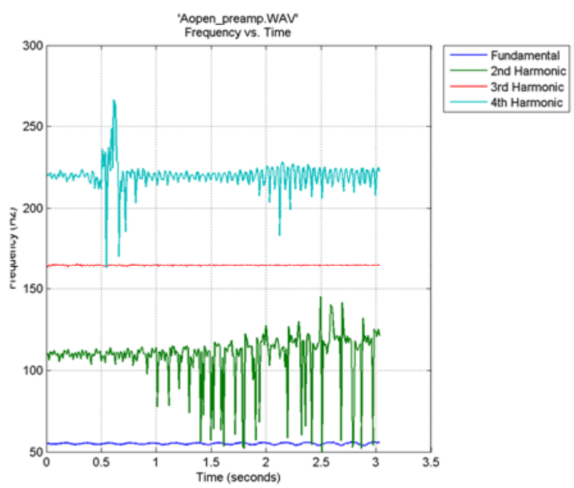
Frequency vs. Time A (Pbass)





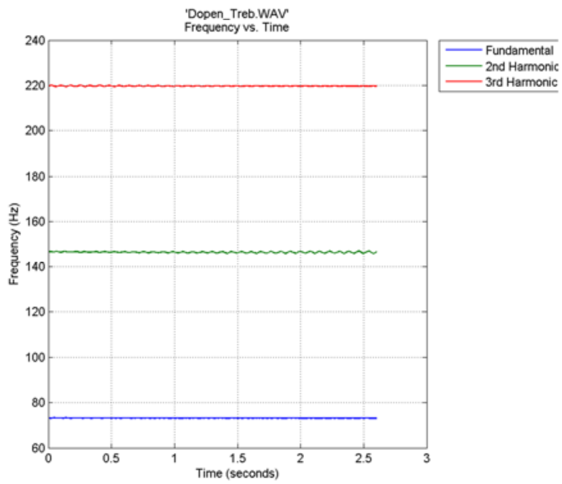
Frequency vs. Time A (Acoustic)

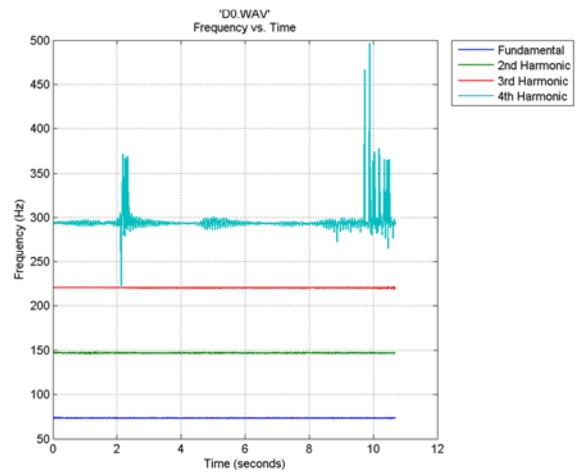




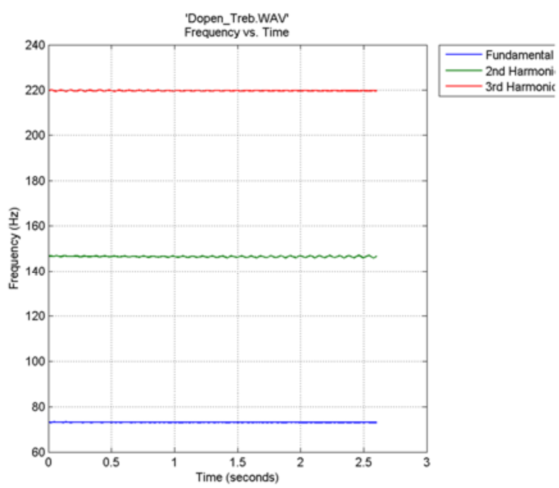
For the open A string, the Squire and P-Bass had very similar responses for the third harmonic while the acoustic varied more for the second and fourth.

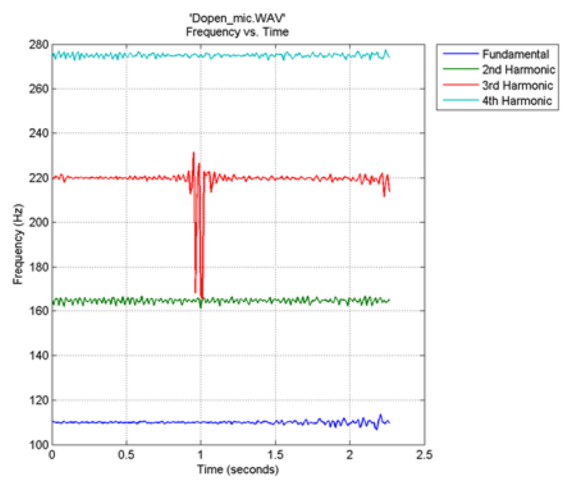
Frequency vs. Time D (Pbass)





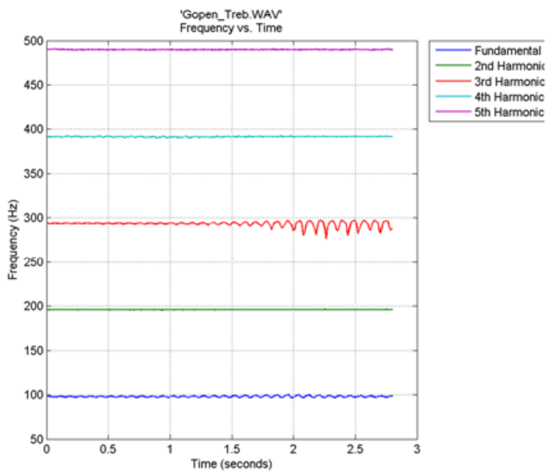
Frequency vs. Time D (Acoustic)

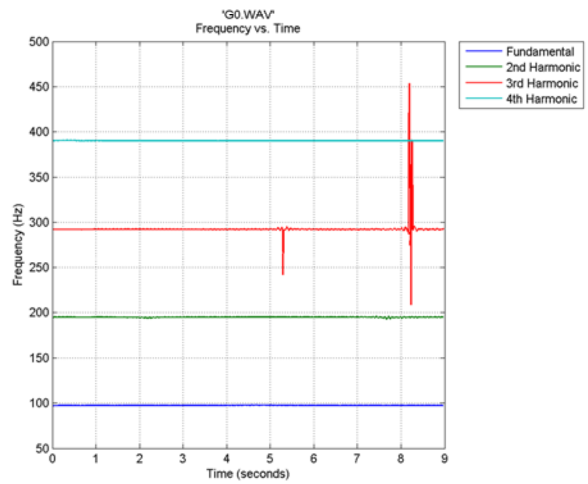




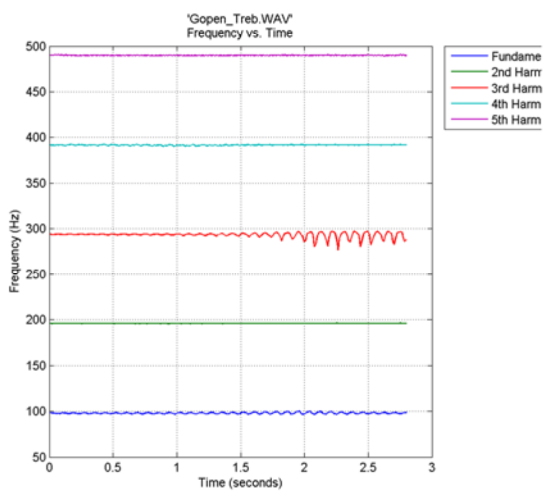
The Squire had flat response for the three significant harmonics recorded. The P-Bass graph ranges from 0-12 seconds, and was flat except for the fourth harmonic. The acoustic had a flat response except for the third harmonic.

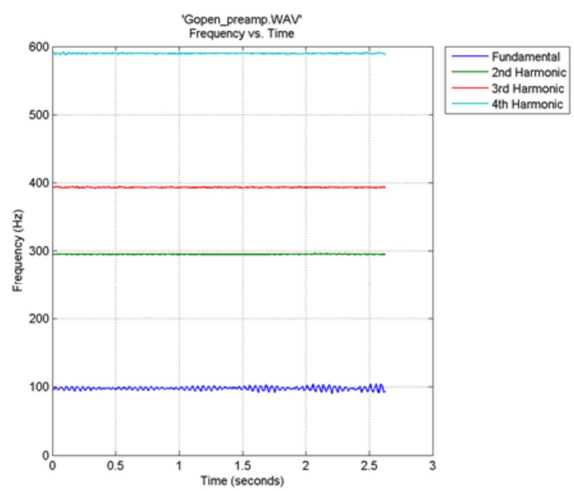
Frequency vs. Time G (Pbass)





Frequency vs. Time G (Acoustic)



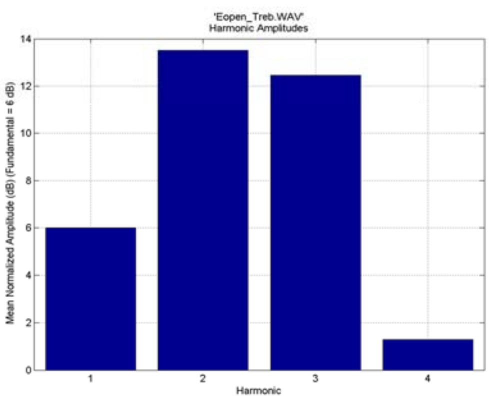


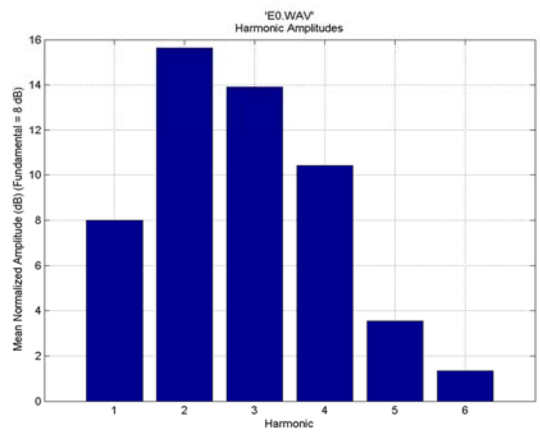
On the higher strings, the frequency vs. time stays more consistent. All three instruments had flat responses.

Harmonic Content

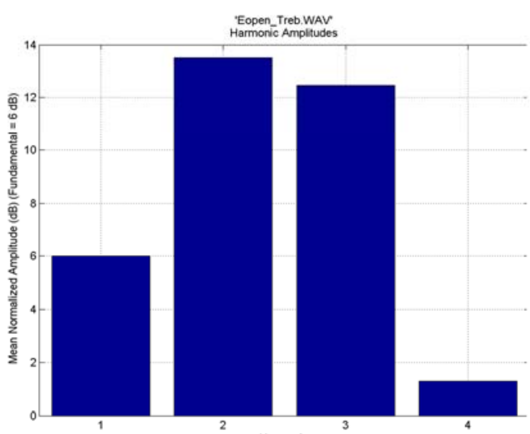
The next graphs compare the amplitudes of each harmonic between the Squire and P-Bass and the Squire and acoustic. It is important to note both the Squire and acoustic had very old strings on them which take away the higher frequency harmonics. The P-Bass had more high frequency harmonics, probably for this reason, than the acoustic and Squire. The acoustic had more high frequency harmonics than the Squire for each string.

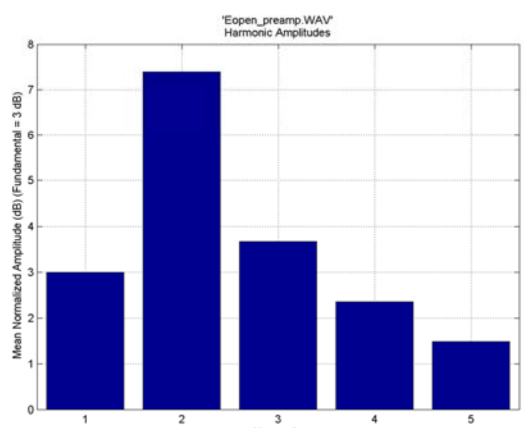
Harmonic content E (Pbass)



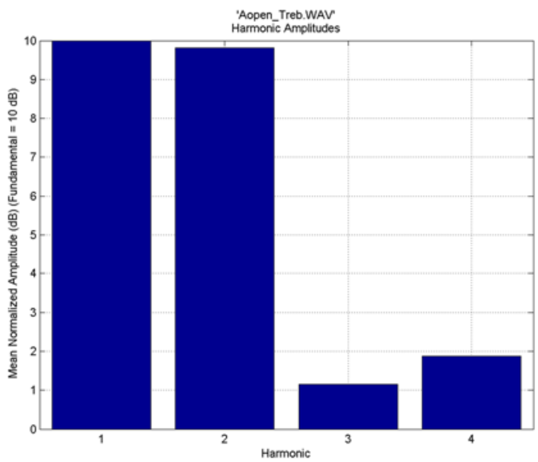


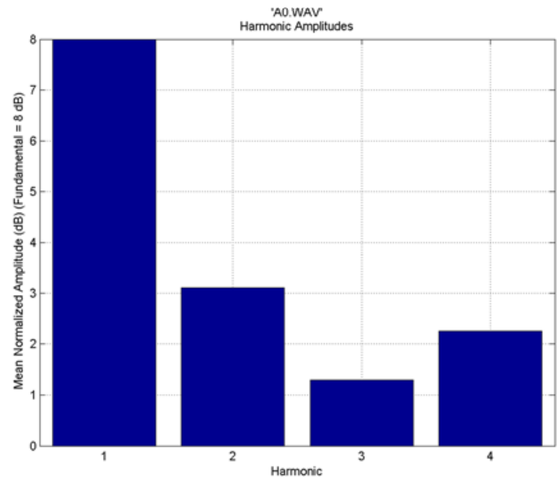
Harmonic Content E (Acoustic)



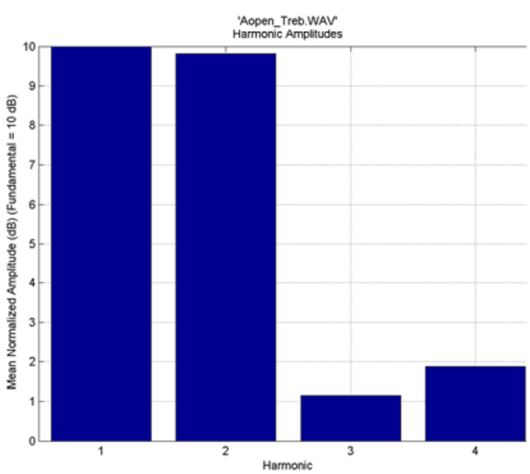


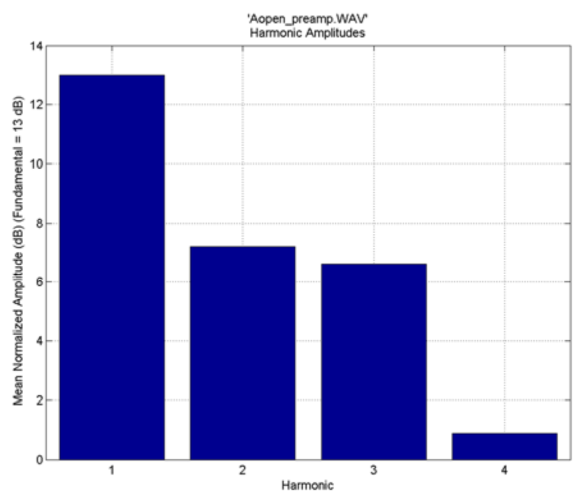
Harmonic Content A (Pbass)



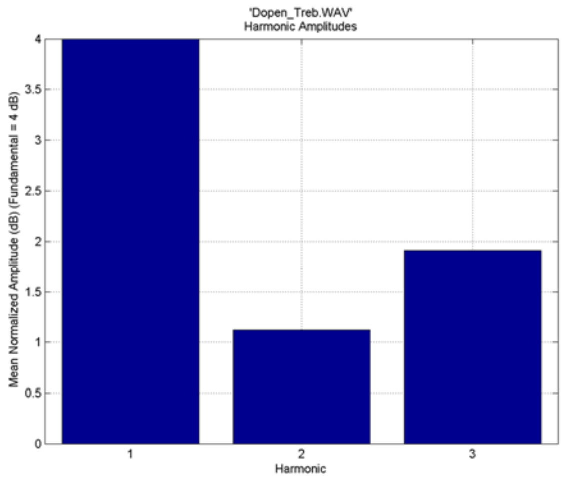


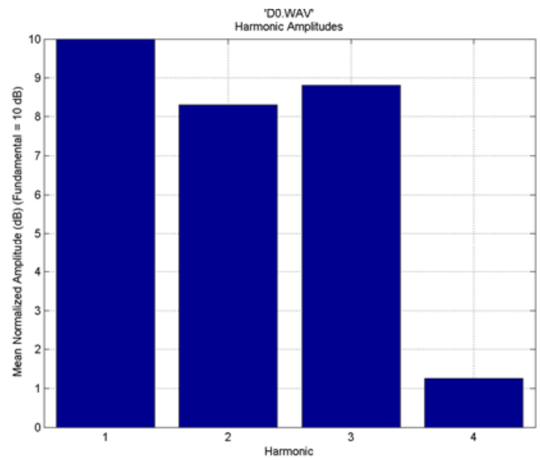
Harmonic Content A (Acoustic)



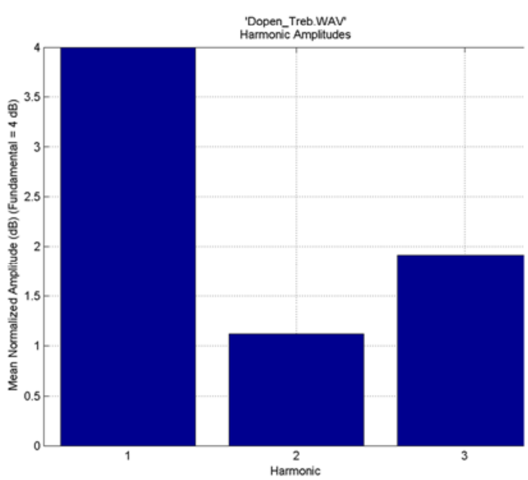


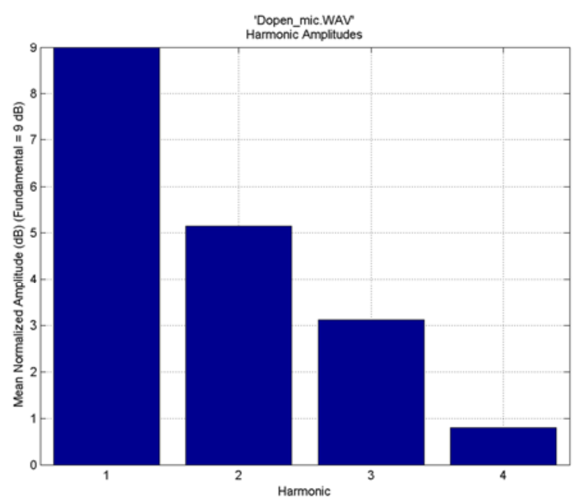
Harmonic Content D (Pbass)



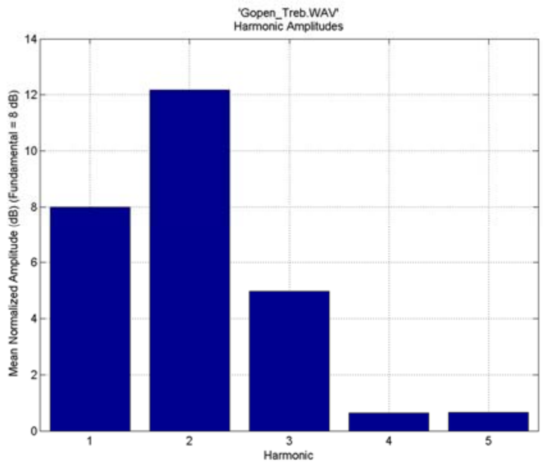


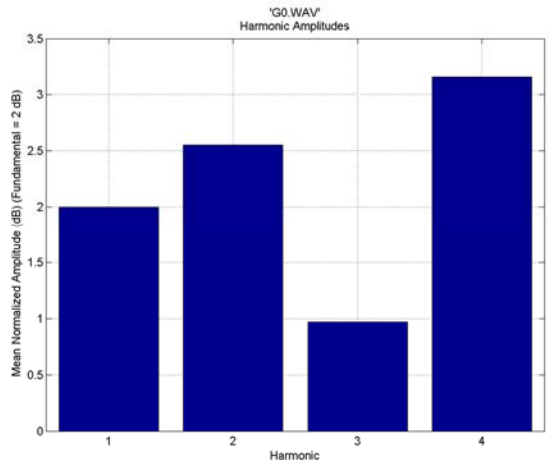
Harmonic Content D (Acoustic)



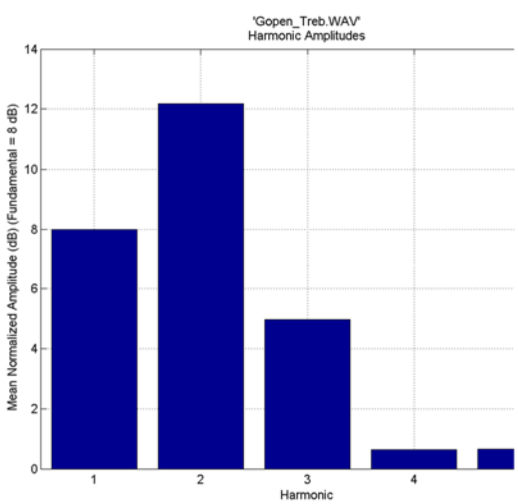


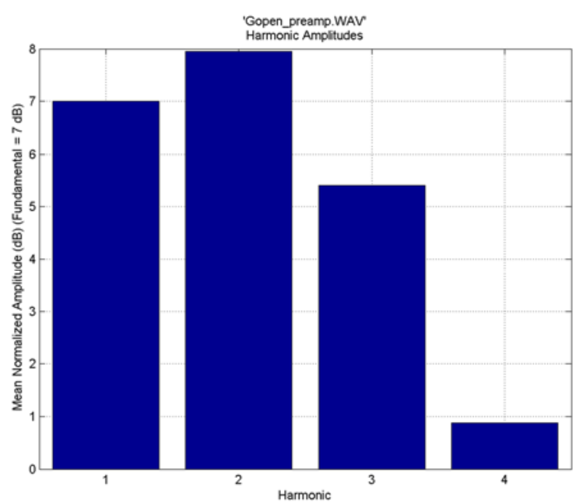
Harmonic Content G (Pbass)





Harmonic Content G (Acoustic)

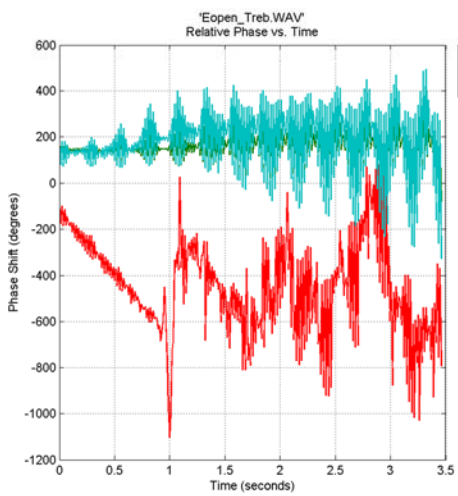


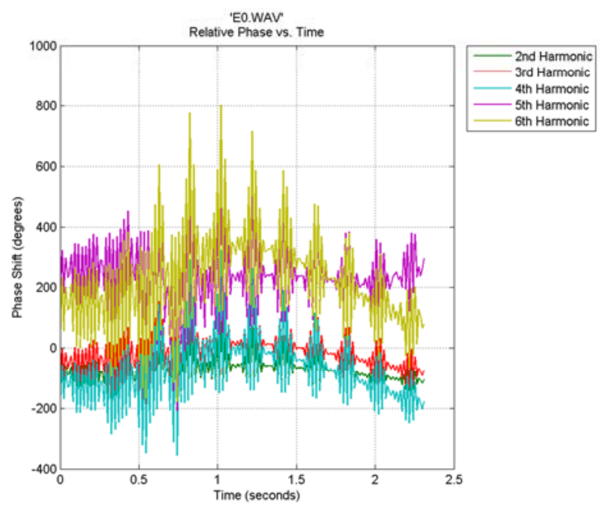


Relative Phase

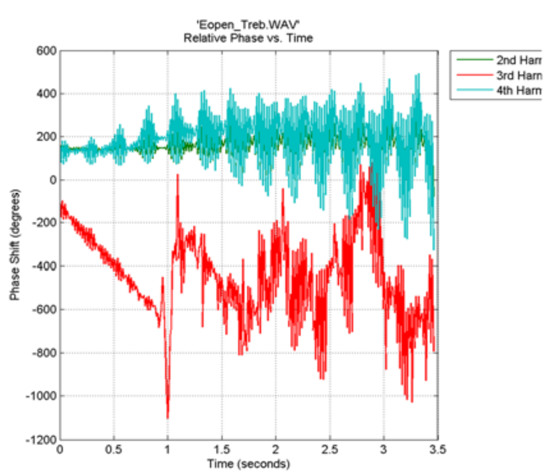
I thought the relative phase to the fundamental was also interesting to look at. The Squire and P-Bass have more similar looking graphs compared to the acoustic (especially the G string).

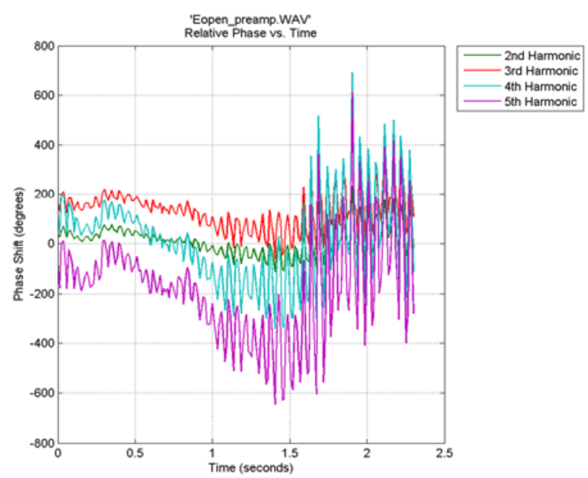
Relative Phase vs. Time E (Pbass)



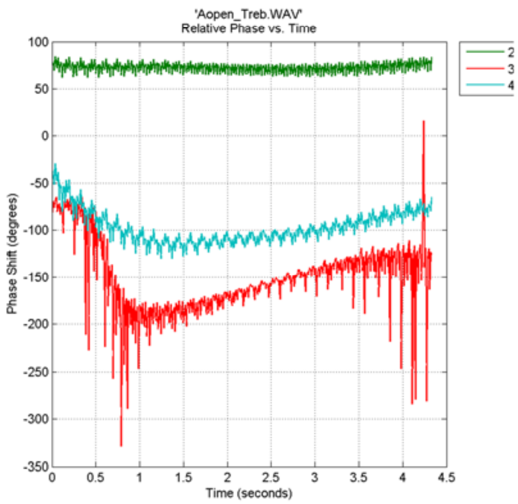


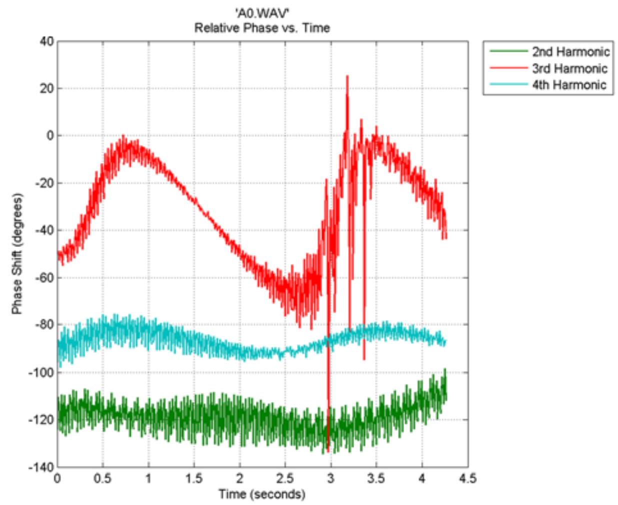
Relative Phase vs. Time E (Acoustic)



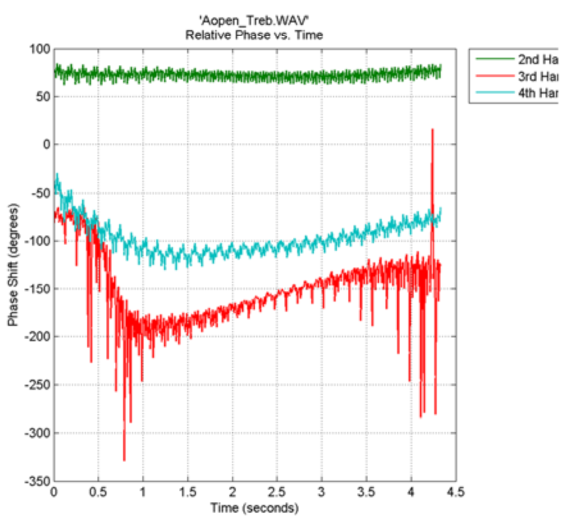


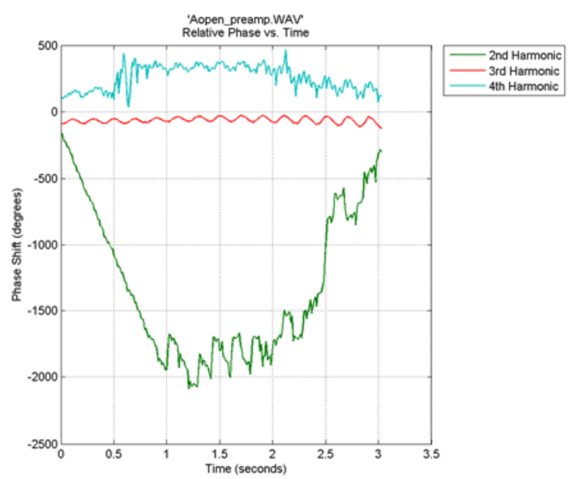
Relative Phase vs. Time A (Pbass)



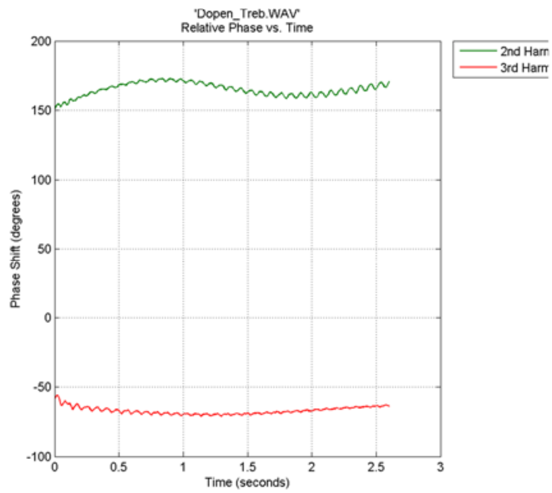


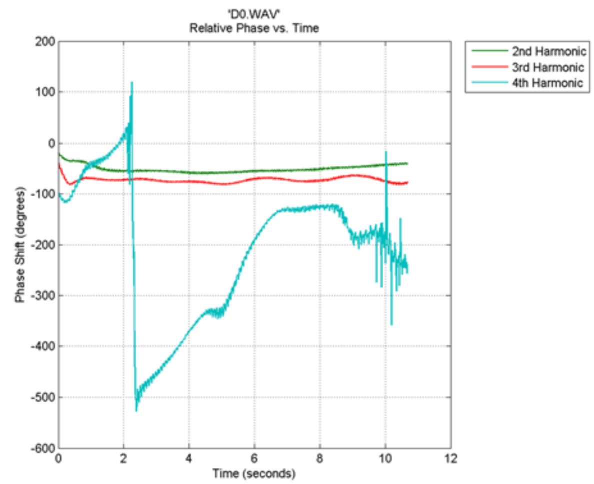
Relative Phase vs. Time A (Acoustic)



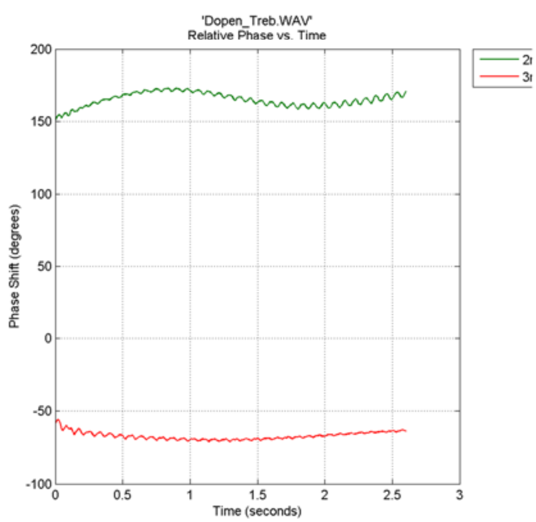


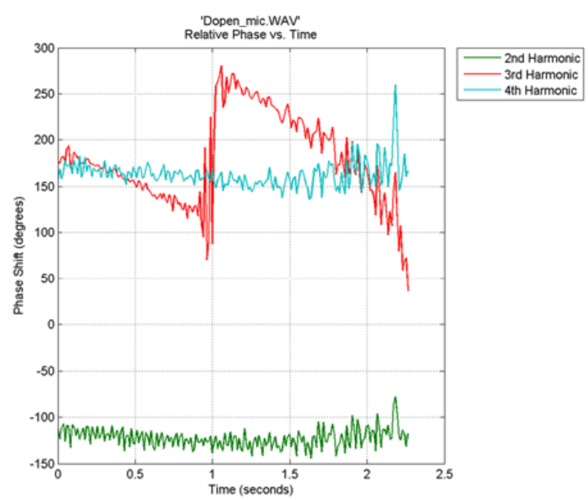
Relative Phase vs. Time D (Pbass)



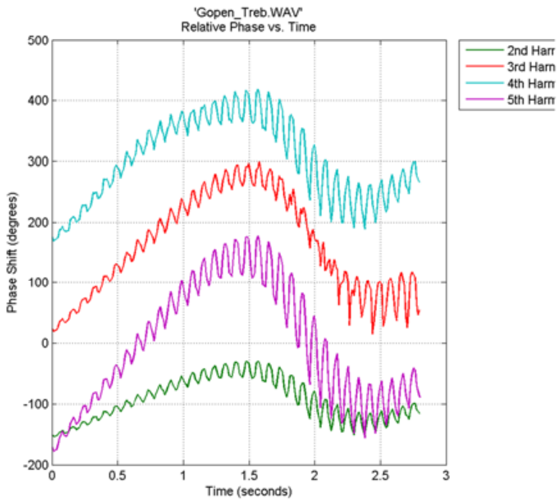


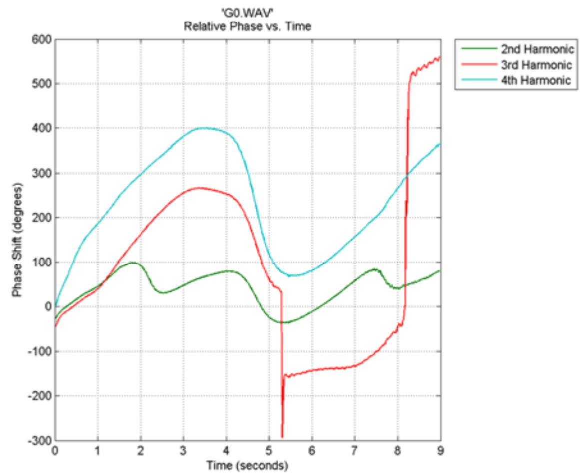
Relative Phase vs. Time D (Acoustic)



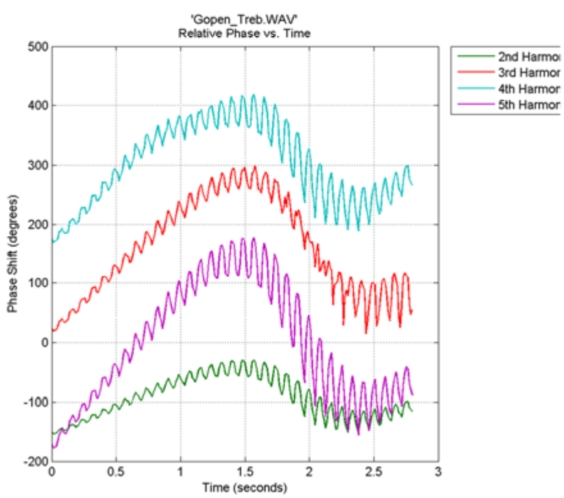


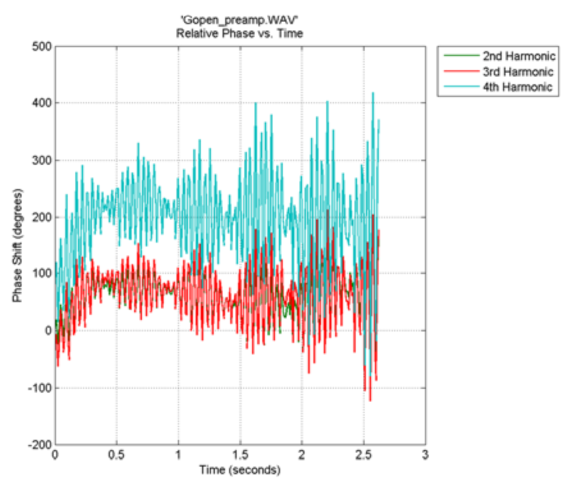
Relative Phase vs. Time G (Pbass)





Relative Phase vs. Time G (Acoustic)

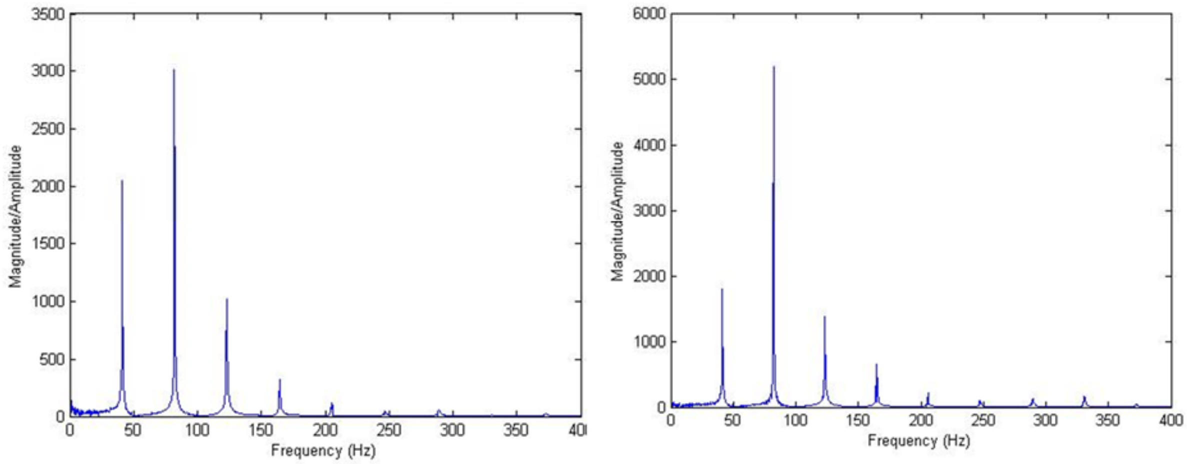




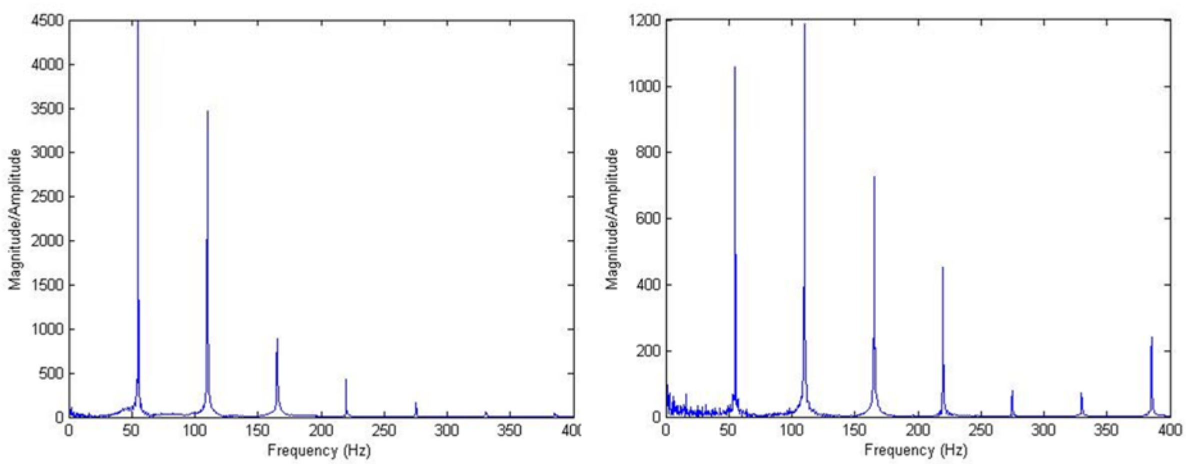
Squire New Strings

For the final part of my project, I bought new strings for the Squire and acoustic and compared the amplitudes of the harmonics before and after changing them. The relative amplitudes of the high frequencies increase dramatically with the new strings.

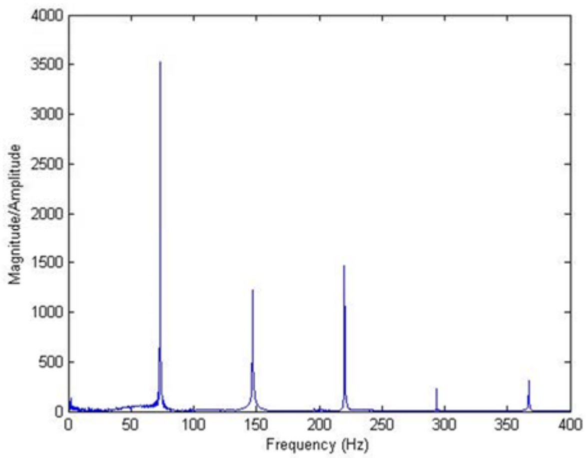
New String Partials (squire) E

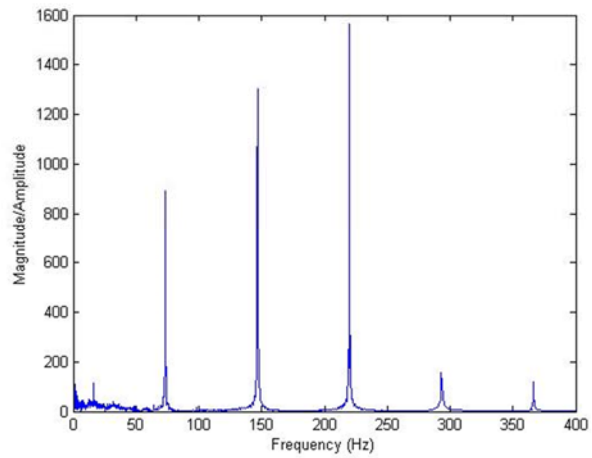


New String Partials (squire) A

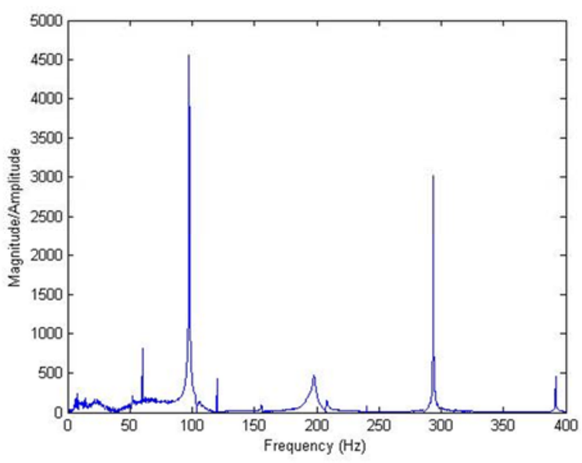


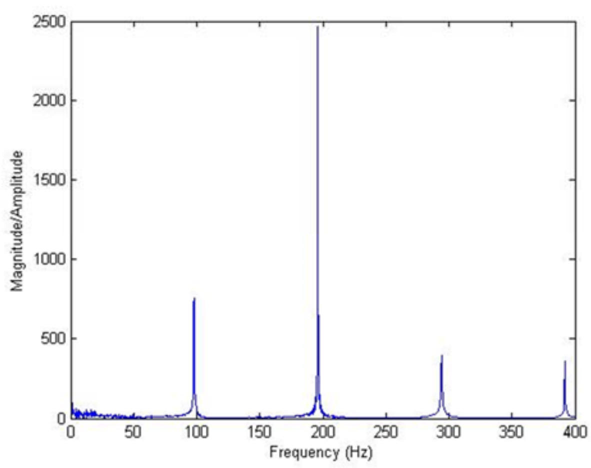
New String Partials (squire) D





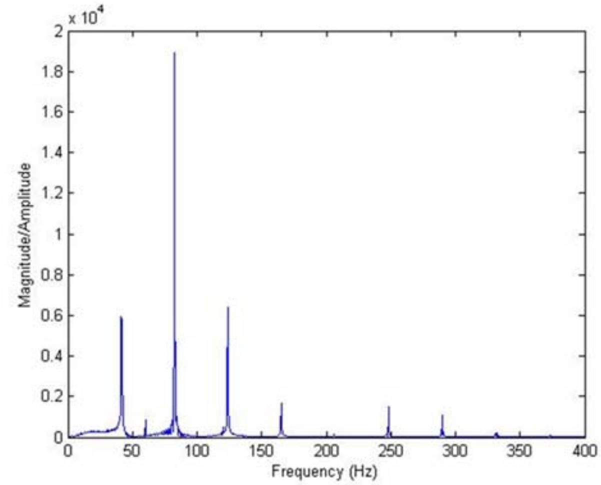
New String Partials (squire) G

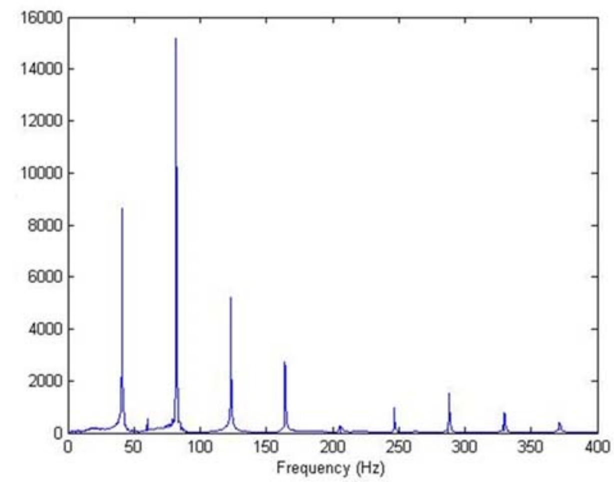




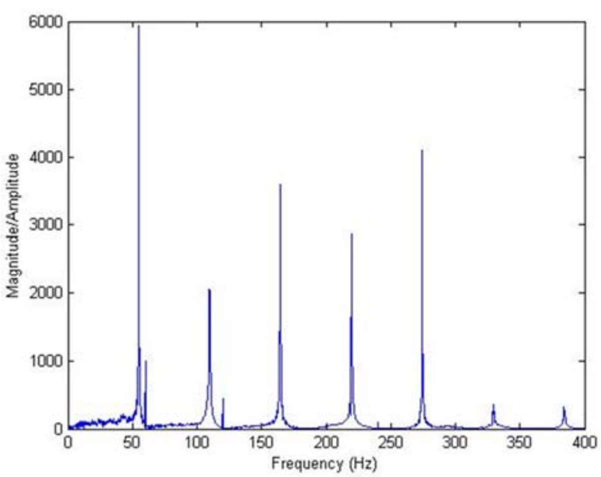
Acoustic String Change

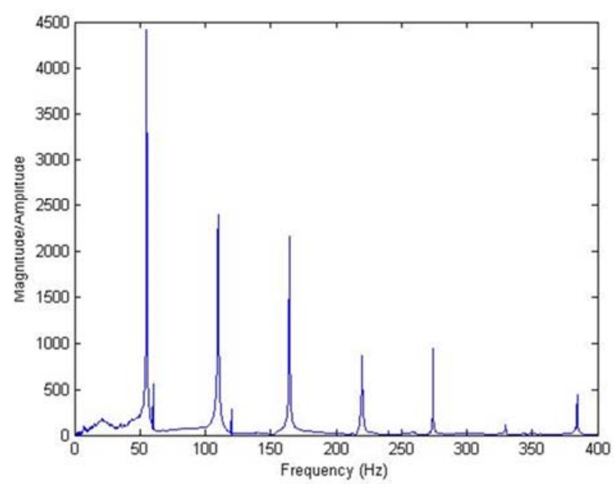
New String Partials (acoustic) E



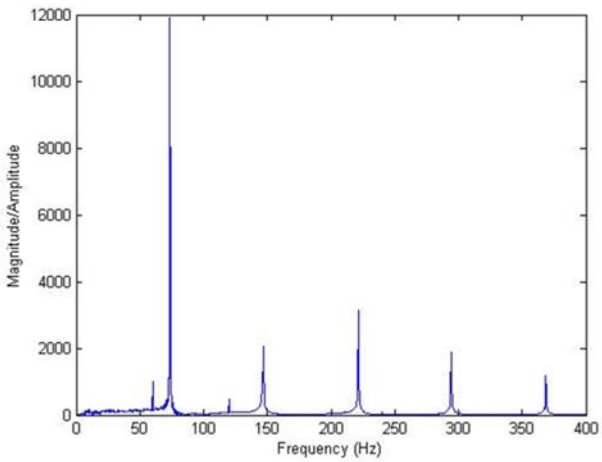


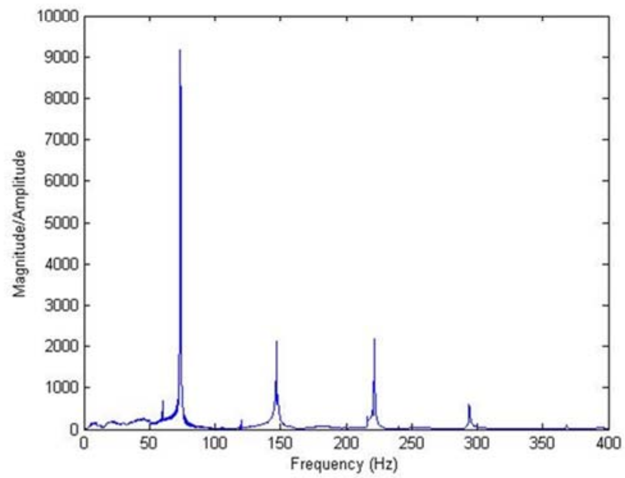
New String Partials (acoustic) A



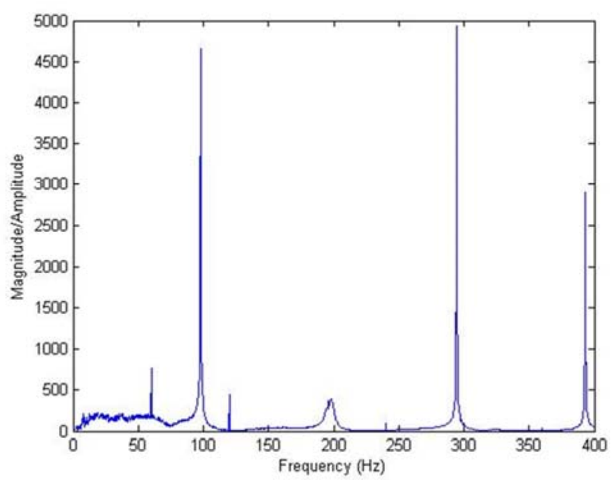


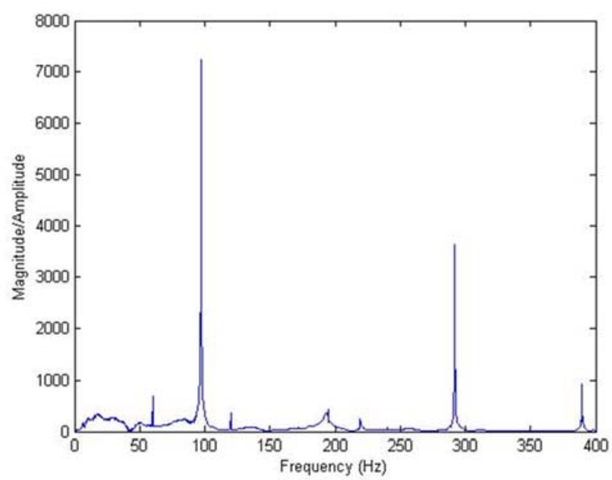
New String Partials (acoustic) D





New String Partials (acoustic) G





The data for the new strings on the acoustic bass did not have the same results as the Squire. The E string had some higher relative magnitudes in the upper harmonics, and the A and D string had higher relative amplitudes in the lower harmonics. In general it seemed that the older strings had a broader range of harmonics. The old strings were bronze while the new strings were nickel, but I still thought the change would be more dramatic.

Summary

After changing the strings, the Squire had a much broader range of harmonics compare to the Acoustic. I was very surprised by how drastic the change was between the old and new string harmonics, but I was surprised how little the harmonics changed for the acoustic. I would like to thank Professor Errede for helping me record and analyze the sounds.

Matlab Script for measuring frequency amplitudes:

http://eleceng.dit.ie/dorran/matlab/resources/Matlab%20Signal%20Processing%20Examples.pdf

- fs = 44100;
-
- bass_guitar = wavread('Gacoustic2.wav', 5*fs);
- ft = fft(bass_guitar);
- mag_ft = abs(ft);
- low_freq_mags = mag_ft(1:2000);
- plot(low_freq_mags);
- N = length(mag_ft);
- freq_scale = 0: fs/(N-1) : fs;
- plot(freq_scale, mag_ft);
- low_mag_freq_scale = freq_scale(1:length(low_freq_mags));
- plot(low_mag_freq_scale, low_freq_mags);
- ylabel('Magnitude/Amplitude');
- xlabel('Frequency (Hz)');