Repair and Investigation of the Ukulele

Physics 406, Physics of Music

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Table of Contents

Introduction:

For my project I wanted to test the acoustic properties and the sound quality of a ukulele with crack. Also, after personal repair, I wanted to test the influence of the crack by comparing the properties before and after the repair. The ukulele in the test was a Kala ukulele I borrowed from my roommate.

Background History:

The ukulele (abbreviated to uke), is a member of the guitar family of instruments. It is a Hawaiian guitar with four courses of strings. There are four types of ukulele based on the size: Soprano, Concert, Tenor, and Baritone. The ukulele used in this lab is a tenor approximately 43 cm scale length and 66 cm in total length.

Motivation:

The first time I learn about ukulele is at sophomore year when my roommate bought his first uke. He practiced a lot and the harmony he plays was so intriguing. The playing style and sound produced is different from guitar and somehow when listening I feel like there was fresh air. To my surprise, it was a well-known musical instrument among people. Since I had no knowledge of the instrument, I decided to study about it. After running the first testing on the ukulele, I examined the data and did presentation in class. During the presentation, a classmate point out that the uke I used had a crack in the back, and he asked if that would affect the sound quality of the instrument. I was aware of the crack, but I did not paid enough attention on it. So after the midterm presentation, I personally repaired the uke with care, and then ran the test again to comparing the difference in data.

The Instrument:

Kala Ukulele

Price: $400

Testing Acoustical Properties:

Getting the chance to learn about the ukulele made me very excited, but I had no idea of what to do about it. Fortunately, Prof. Errede taught me that studying the mechanical resonance could be a wise first move. This was achieved by using two different piezoelectric transducers at six positions on the body of the ukulele and a pressure and particle velocity microphone in the hole. Prof. Errede was generous enough and put a huge amount of effort in setting it up and running the test. Adding AC voltage of certain frequencies will trigger the vibrations of a piezoelectric transducer. One piezoelectric transducer vibrates at a certain frequency and the other collects data respectively. The result was quite surprising to me. For the Kala ukulele I used in the test, it has around 21 resonances, which is much more than that of guitars from previous student projects. It also has around 24 anti resonances. The highest resonance occurs at around 1799.5 Hz.

Repairing Ukulele

There was a long crack at the bottom of the ukulele's back. In order to fix the ukulele, I searched several methods online and chose the most reliable one to conduct. After getting permission from the uke's owner, my roommate, I bought wood glue and did preparation for the repair. The first step was to get a clean and comfortable working table to place the uke. I cleaned the ukulele and applied wood glue on the crack. For the crack to absorb the glue, I need to tap the glue with my finger repeatedly. Then I put the uke on the table and gave it 20 minutes to soak in the glue. When it is done, I put the uke in the case and used a humidifier to avoid further damage and enable repairing.

Second Time Testing

The set up of second testing is the same as the first time. Difference is that I did not had the idea of doing the test again at first and thus did not mark the position where the piezoelectric transducers placed. It might affect the result, but there are two reasons to believe it did not. Prof. Errede was wise and careful enough to set up the test and the position he placed the elements were almost the same as before. Moreover, by comparing the particle velocity and displacement collected in the two tests, they were almost the same. The comparing result was quite interesting. Overall, there is not much change for the ukulele, but by looking at the details, fun facts can be found. There are errors in some data, but all the following results are corrected after careful study. After the repairing, the data showed more resonances and less anti resonances. This means there are less dead sound produced and the general performance is more harmonic. This is a good thing and when my roommate plays this ukulele, he also mentioned is sounds better. Nevertheless, the sound intensity somehow decreased after the repairing, and the sound produced is weaker than before. It was unexpected but very surprising. It is also fun that when I presented this founding to the class, one classmate mentioned that we could intentionally make the sound brighter by making cracks on the instruments if my research is true.

Conclusions:

PHYS 406 is nothing like other physics class I have taken. I found the class very rewarding and fun. I learned to study the data collected from the instruments and how different characteristics influence the performance. I also learned about ukulele and experienced various instruments in the class. In addition, the repairing made me realize how hard people created the instruments by careful consideration of every small detail. My respect to people working on music grows and I had a more comprehensive idea of lab projects than I did in the beginning. The class is really inspiring and I would like to recommend it to those students who are interested in music.

Special Thanks:

Prof. Errede for all the assistance in the lab and help me understand all the data

Reference:

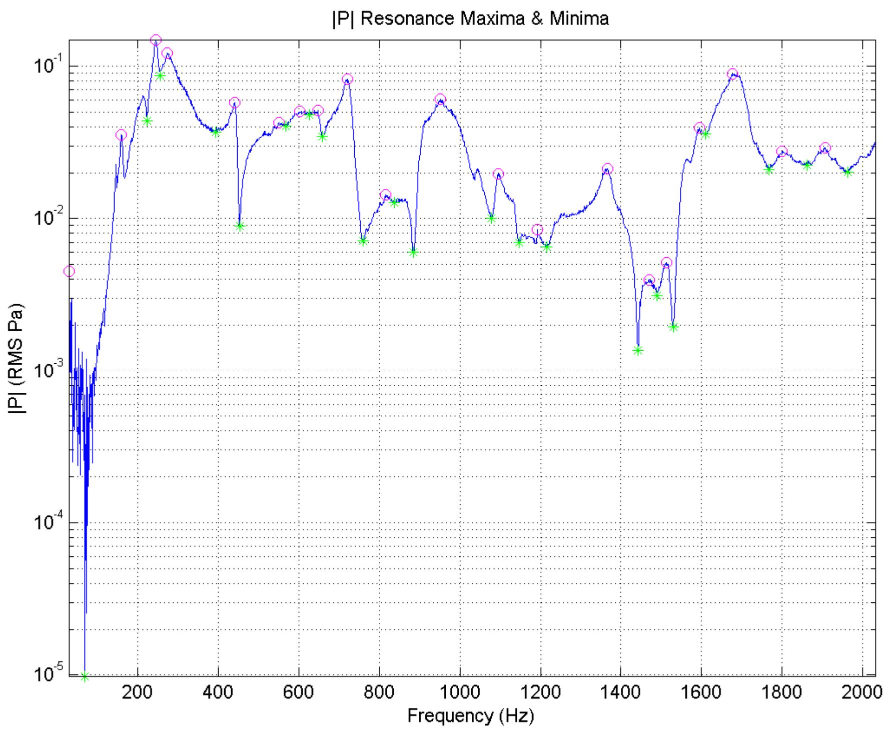
Erich M. vo Hornbostel & Curt Sachs, "Classification of Musical Instruments: Translated from the Original German by Anthony Baines and Klaus P. Wachsmann." The Galpin Society Journal 14, 1961: 3-29

POM 406 class website material

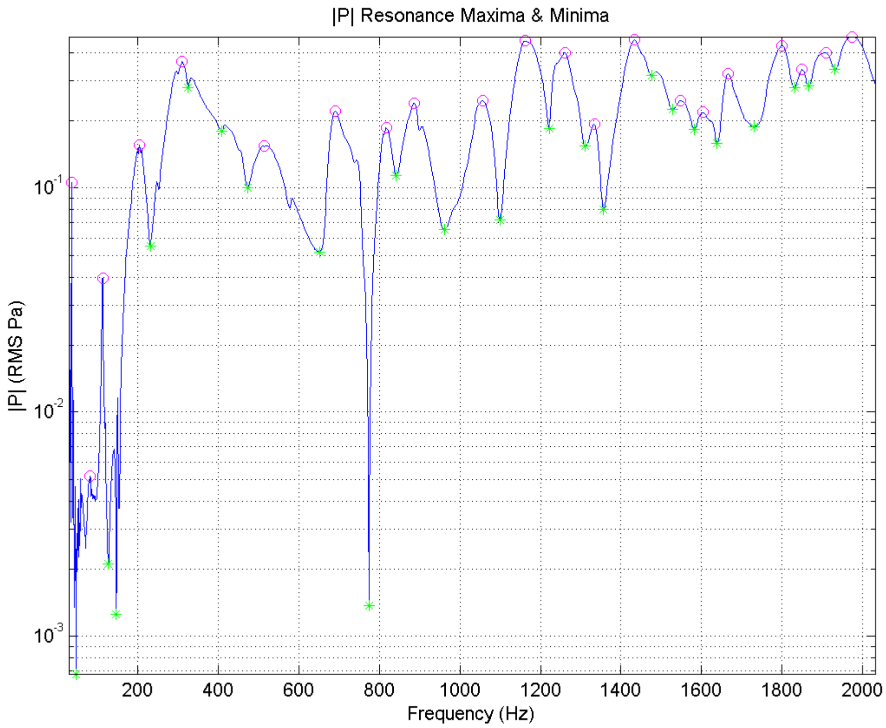
Some Data

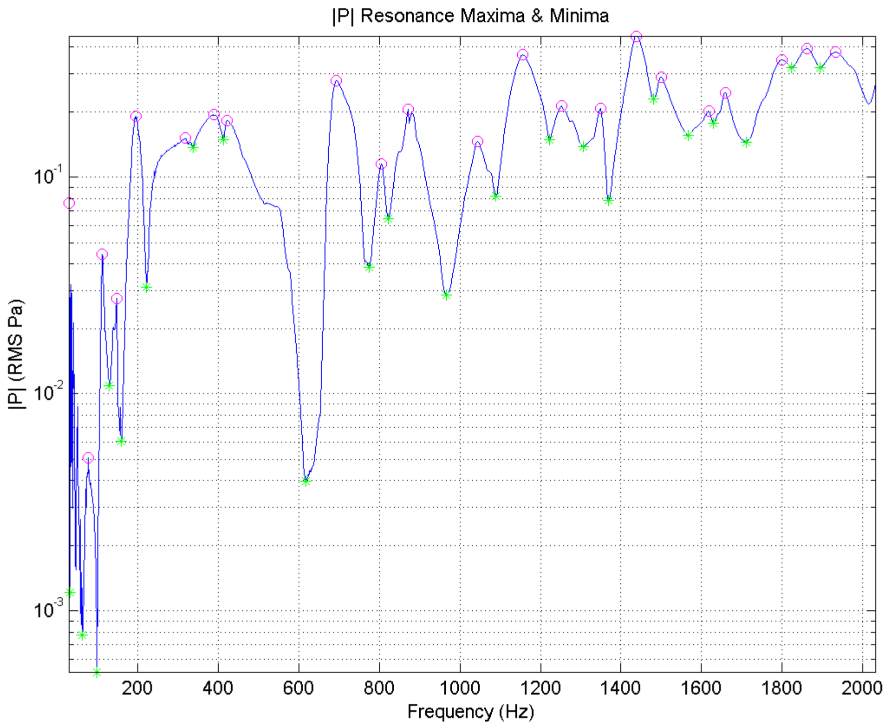
Vfg = 1.0 RMS Volts @ CV => PZO Xmtr
Pmic (PU nano-mic # 1) ADC0,1 200 mV
Umic (PU nano-mic # 4) ADC2,3 100 mV
PZO Rcvr ADC4,5 1000 mV
Accel Xdcr ADC6,7 100 mV

Makala BRG 20:21

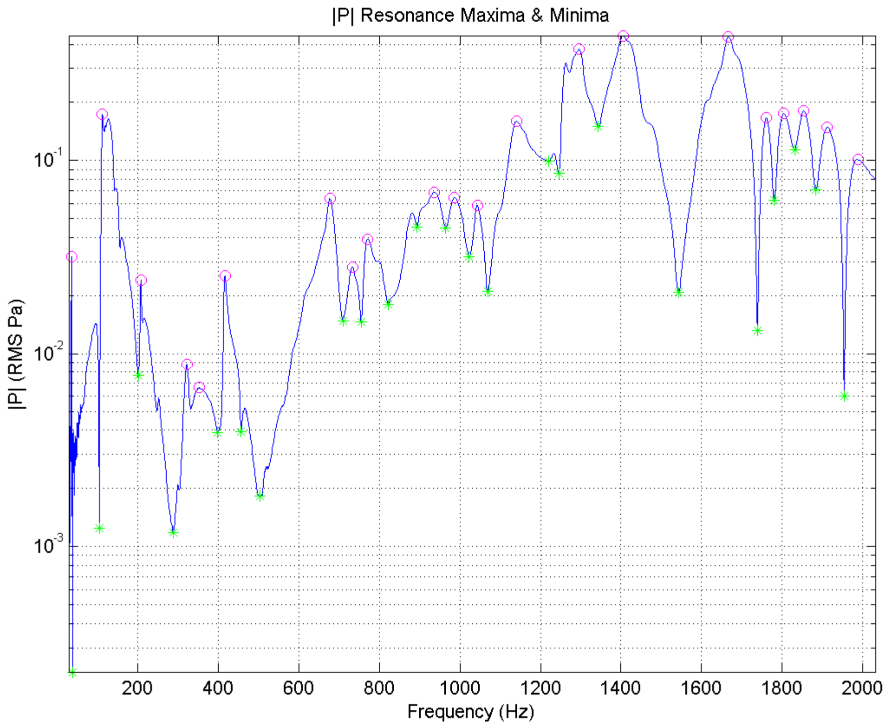


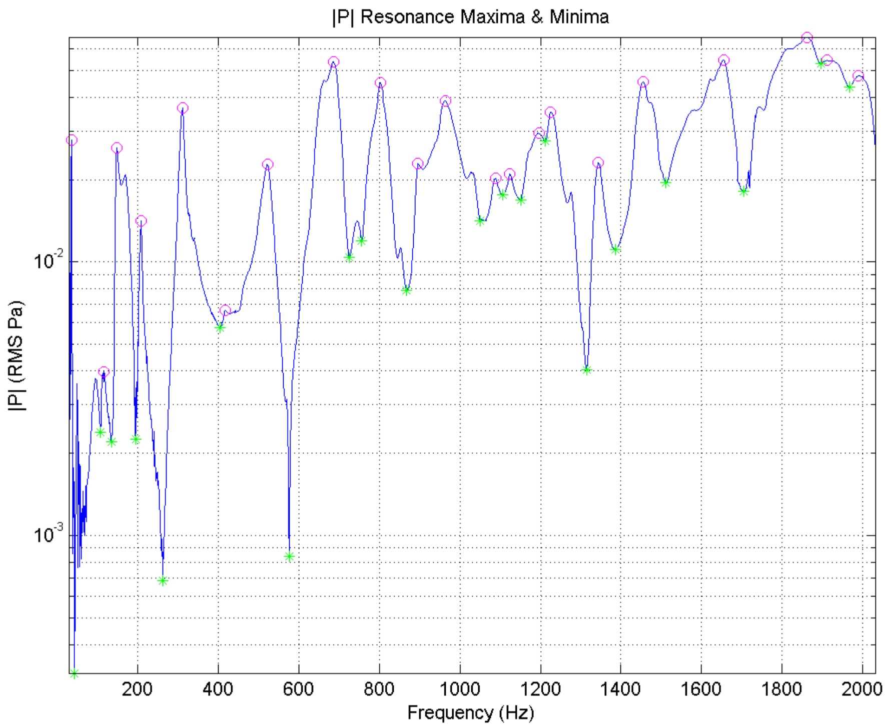
Kala Bridge   Maxima: Minima: 1. (21:23); 2. (23:22)





Bottom Right Bout 1. (21:23); 2. (21:20)





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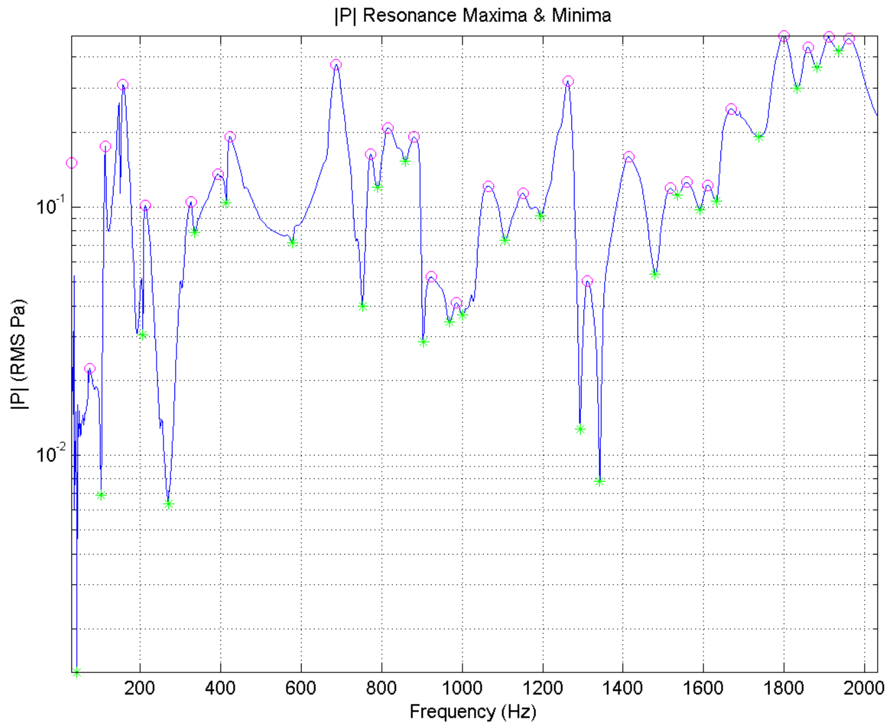

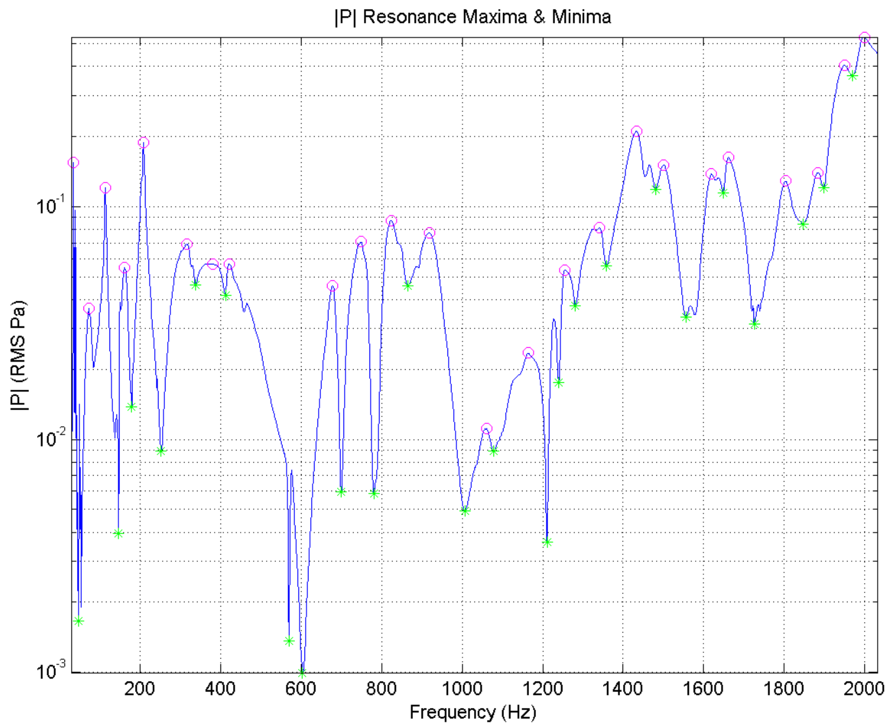

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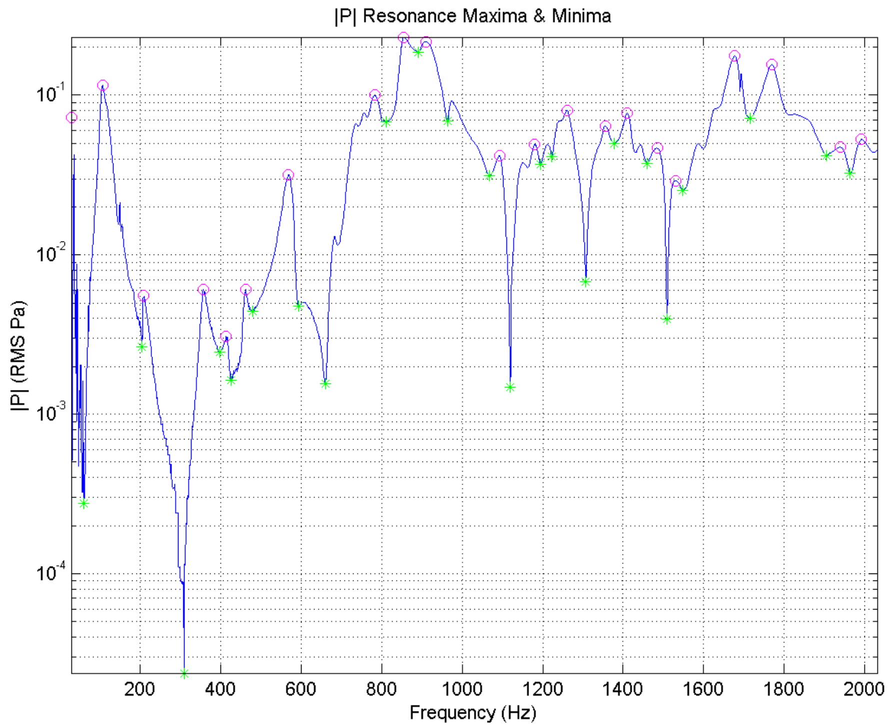

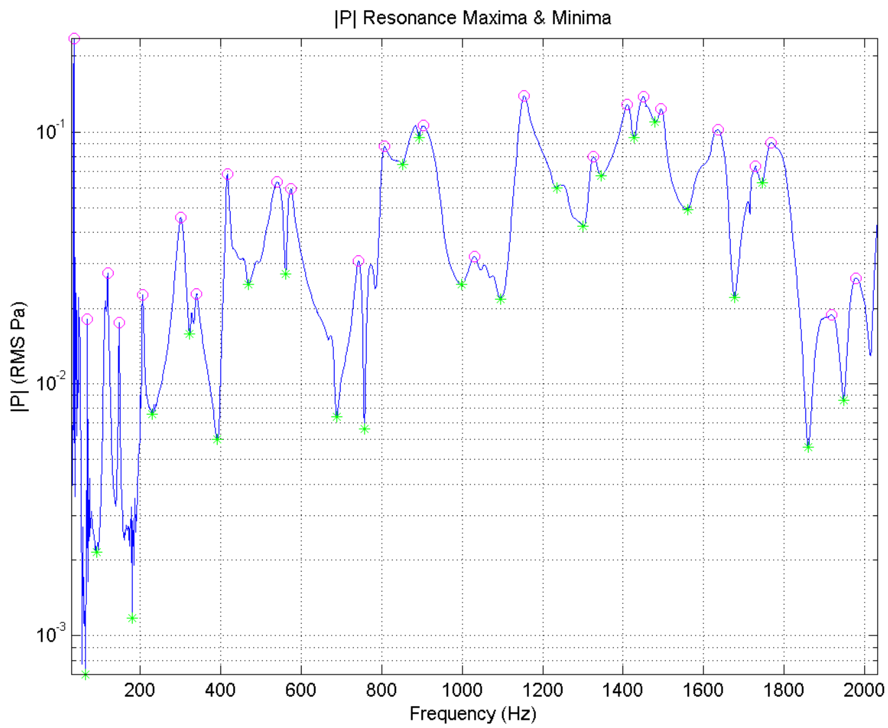

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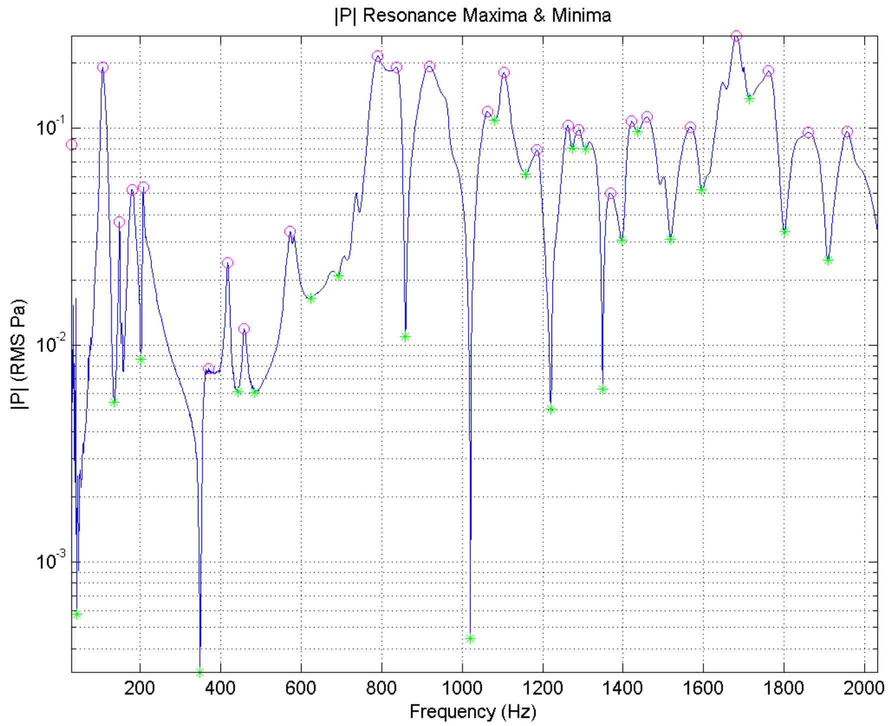
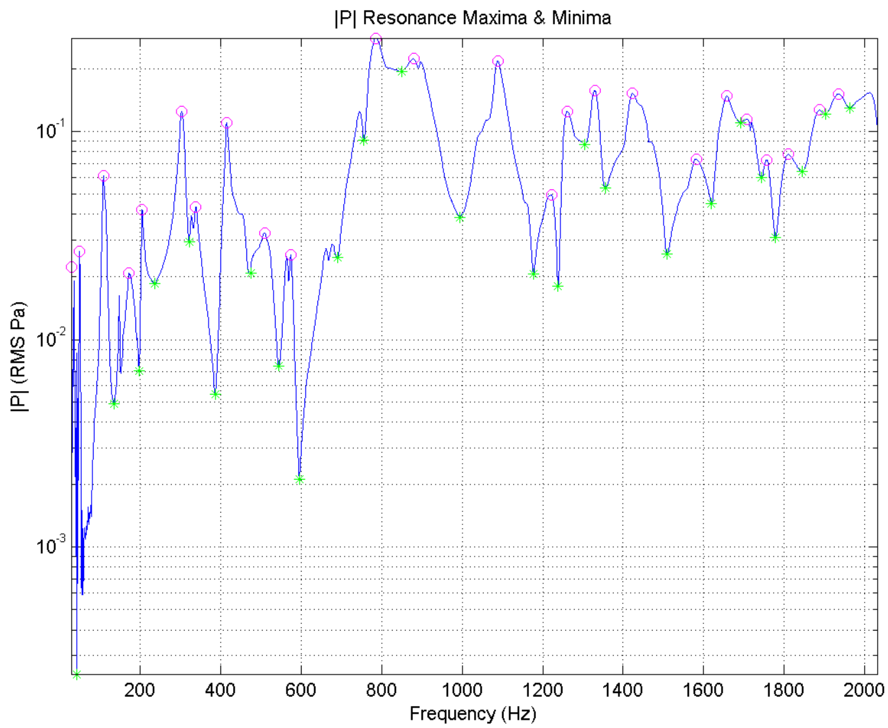
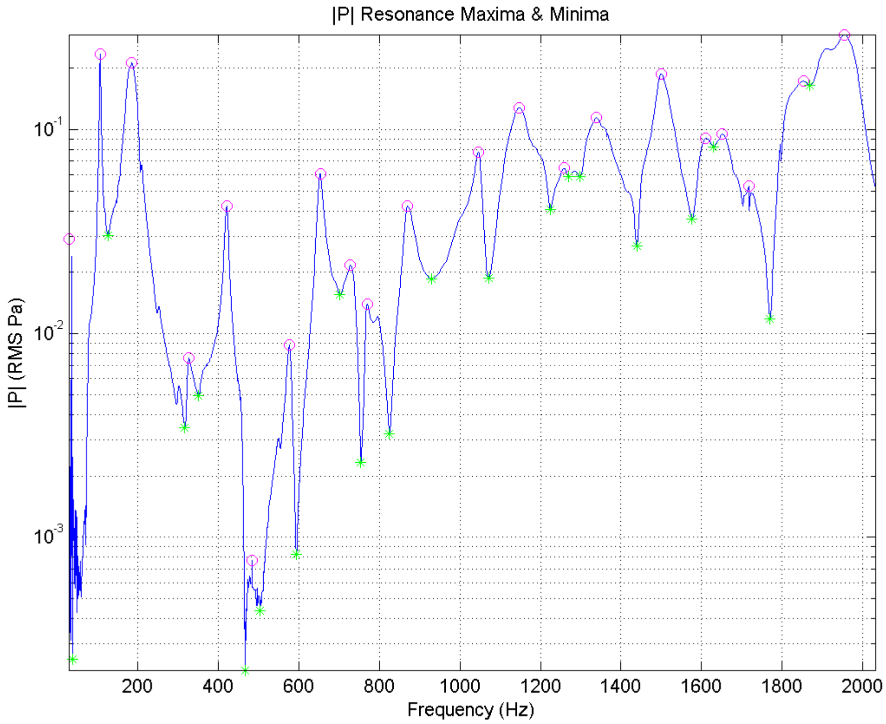
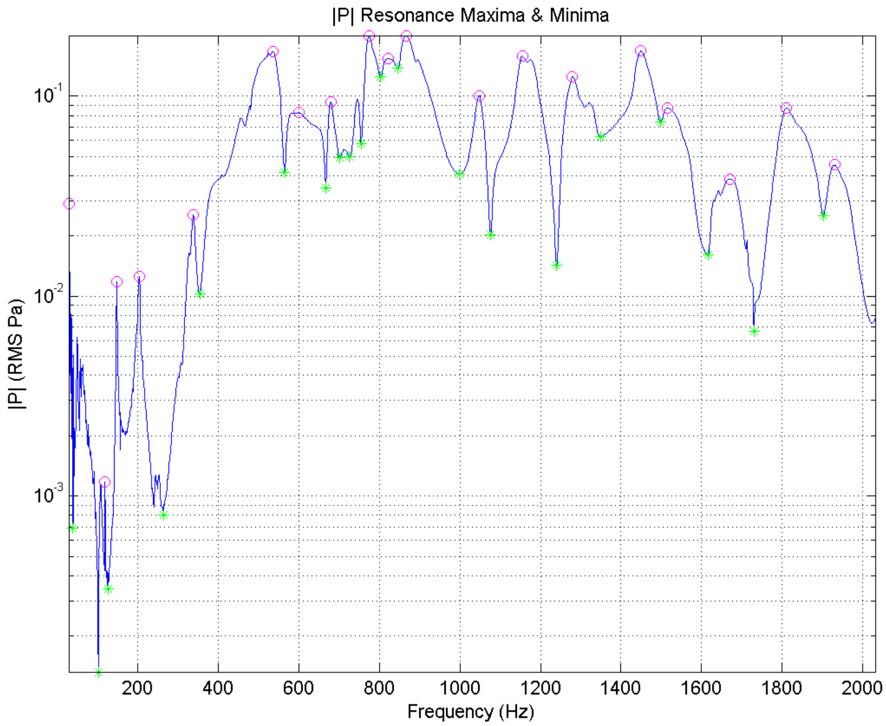


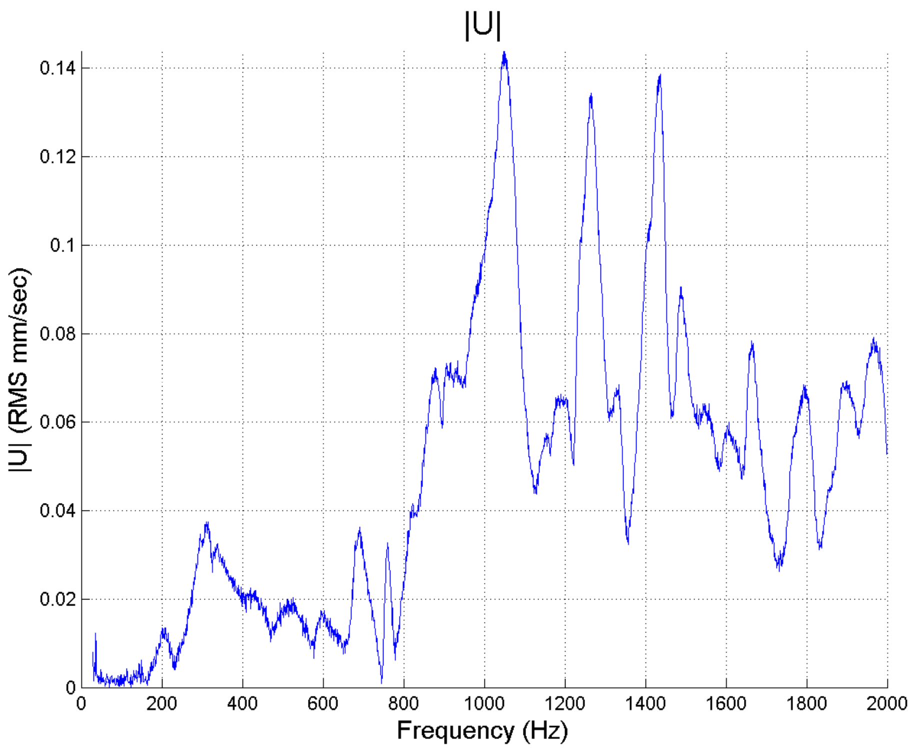


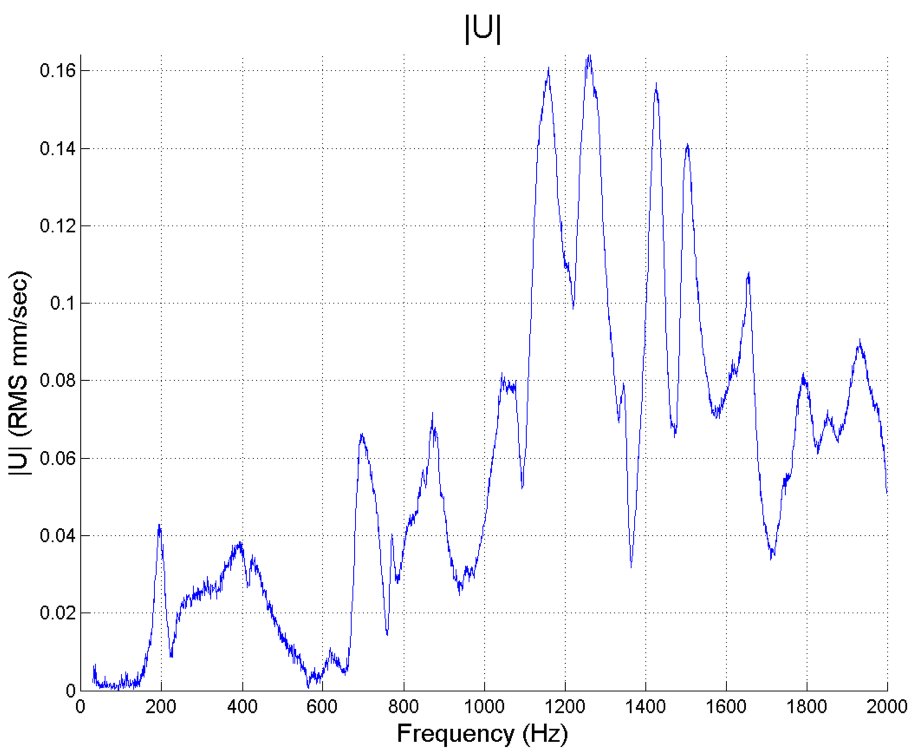
Head Stock 1. (21:20); 2. (19:20)



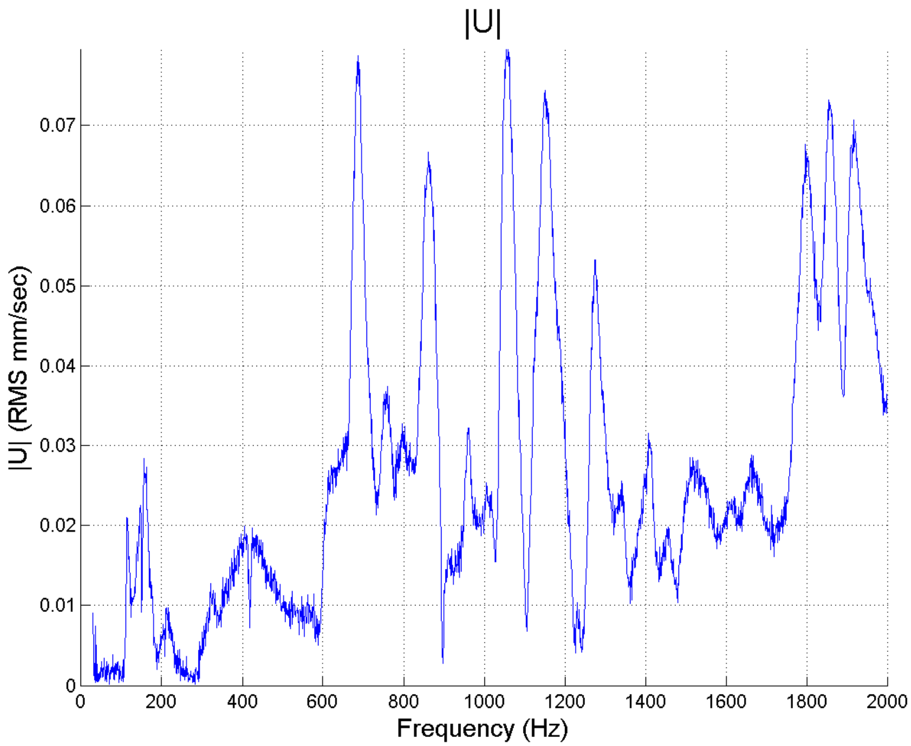


Energy range at bridge 0.14373684174, 0.16412037974





BLB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1600
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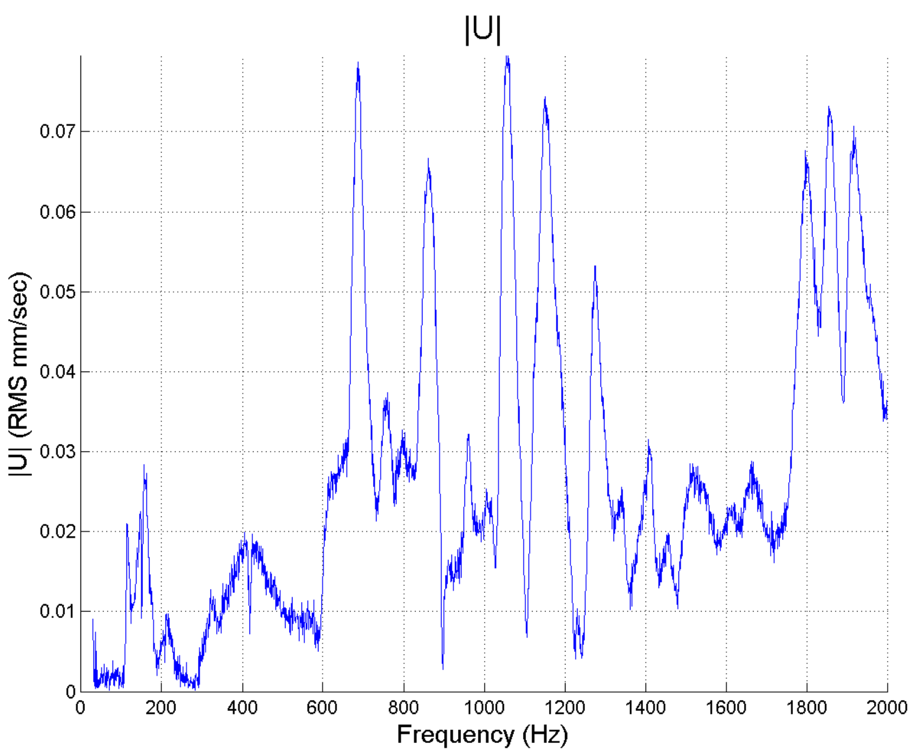
2000
Frequency (Hz)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Frequency (Hz)