Characterizing of 3 Speakers

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Introduction

I have always been interested in what makes two speakers different from one another. Why are some brands so much more expensive than others and how exactly does that affect the sound quality. In order to answer these questions it was obvious that I had to characterize these speakers and compare the results I received. This way I could really see whether or not different types of speakers are worth the money they cost and how much of a difference it really is. In order to get a wide range of speakers I tested 3 different speakers. A Klipsch KG2 is expected to give the best response followed by a GE G501 and lastly an Akai, which is expected to give the worst response. The data to be examined is pressure, particle velocity, impedance, and current all plotted against frequency. This will allow for the performance at individual frequencies of each speaker. There is also a measurement of coherence, extremes of the impedance and a graph of the sound pressure level (SPL), sound intensity level (SIL), and the sound velocity level (SUL). With all of these graphs, the response of each speaker can effectively be compared.

For this evaluation, two different testing designs were used. First, the Akai was tested using 4 lock-in amplifiers. The downside of these tests is that the amplifiers take a very long time to calibrate and capture the data. Each of these tests took approximately 7 hours and if there was a malfunction or mistake in the data, it would have to be taken from the beginning again. Once it was clear that this was a good way to get quality data but not practical for a large quantity of data, it was decided to use a spectrum analyzer and a signal generator. This method gave us immediate results, which could be saved for each individual speaker and completed much faster than the lock-in amplifiers.

Procedure

The first method that was used to measure the response of these speakers was using 4 lock-in amplifiers. The only speaker that this procedure was used on is the Akai speaker, as it was determined to take to long to test all speakers with this method. We mounted the speaker on a stool about all the desks, computers, etc, in the room in order to minimize random reflections as much as possible. Approximately 15 feet away from the speaker we used acoustic padding in the form of a chevron in order to deflect the waves towards the sides of the room as opposed to reflecting them directly back to the microphone which was placed on a stand so it was approximately 1 meter from the diaphragm of the speaker. This setup can be seen in figures 1, 2, and 3 below. We connected this setup with a signal generator which was used to step from 20 Hz to 20,000 Hz in steps of 10 Hz. While this was stepping through, the program running was capturing data to be used for approximately 60 different plots of the pressure, amplitude, electrical impedence, acoustical impedence, phase, etc. We were prepared to take the speaker cabinet apart to test the tweeter, woofer, and crossover seperately in order to get a very accurate characteristic of each individual piece. However, when we took apart the speaker we found that there was no crossover, meaning the woofer and tweeter were getting the same signal, so there was no point to separate the two. This is also how we determined that this speaker is the cheapest of the set.

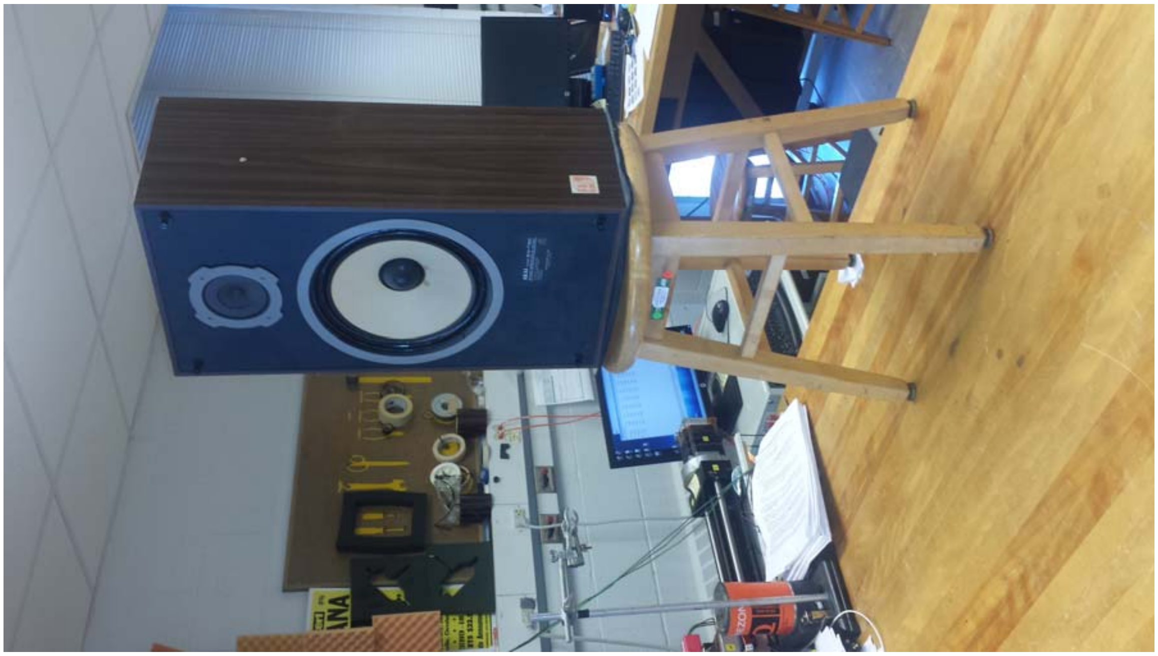

Figure 1: Speaker mounted on top of a stool

Figure 2: Acoustic padding used to deflect sound waves towards the walls

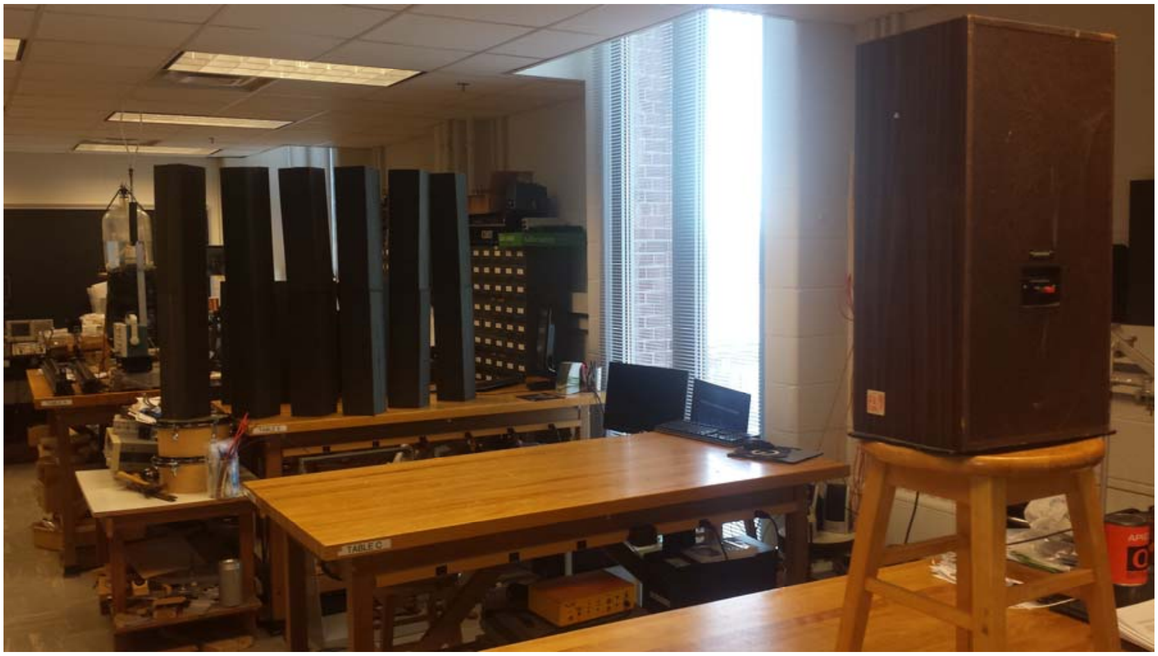

Figure 3: Entire set up in lab.

In order to compare the performance of multiple speakers instead of a single speaker, we used a spectrum analyzer to speed up the process. This included of using a microphone, spectrum analyzer and signal generator. With this setup, seen in figures 4 and 5, the graphs mentioned earlier were accessible much faster. The evaluation went from 20 Hz to 20,000 Hz with steps of 100 but was still able to get a very accurate description of what was occurring.

Figure 4: Klipsch Speaker being tested with the Spectrum Analyzer

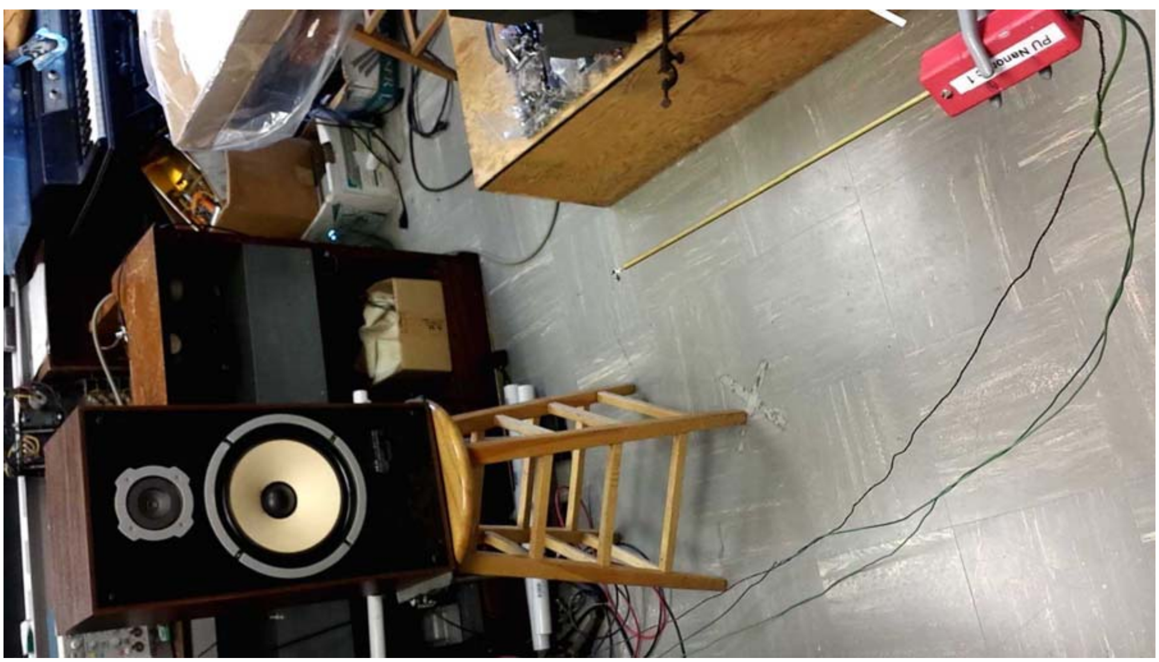

Figure 5: Akai speaker being tested with the Spectrum Analyzer

Data

In the figures below you can see the responses of each speaker. The first six plots are of the current magnitude and impedance, individually, vs frequency. It can be seen here that the current and impedance are performing as expected since they are inverses of each other. It can be seen that when the current is at a minimum the impedance is at a maximum. Once response is analyzed we can come to the conclusion that the higher the current draw of the speaker the higher the response will be.

Comparing the response of the three different speakers via figures 12, 13, and 14, allows us to properly determine the response of the speakers. In this way, we can determine which speaker is 'the best' (I put this in quotations since speaker quality can be arbitrary per listener). In each of these graphs the sound pressure, intensity, and velocity levels are graphed versus frequency. One thing to note with this is that every plot has a significant dip at approximately 6 kHz. Since this is consistent in every plot we received from testing, including the impedance and current plots, it is assumed that this is a result of the testing procedures used. Whether it was a resonant frequency in the room, deconstructing with the generated waves or something with the mic receiving the sound.

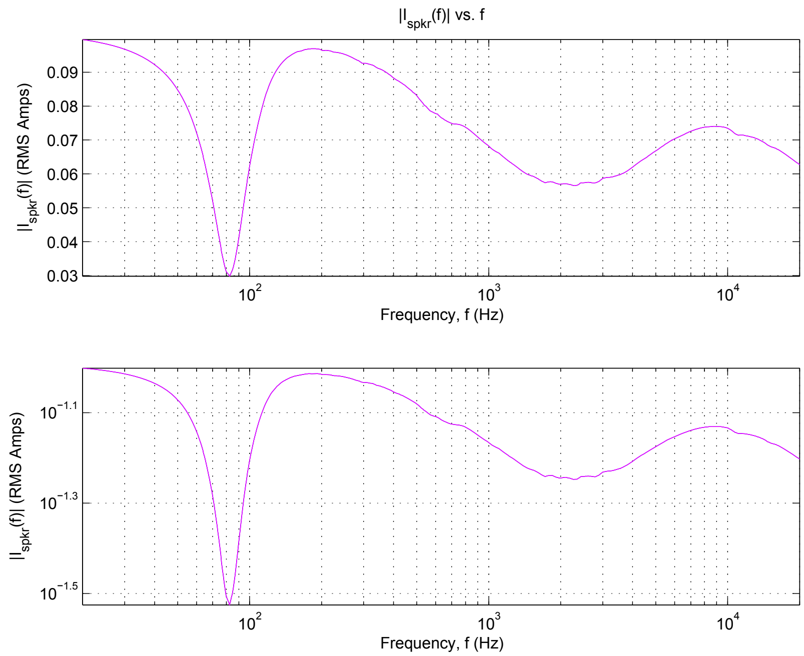

Figure 6: Akai – Current Magnitude vs Frequency

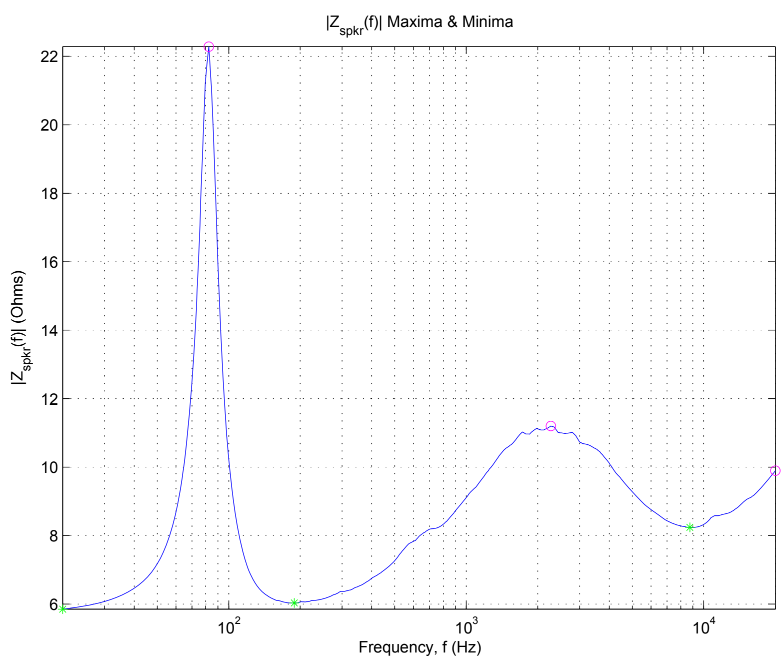

Figure 7: Akai – Impedance vs Frequency

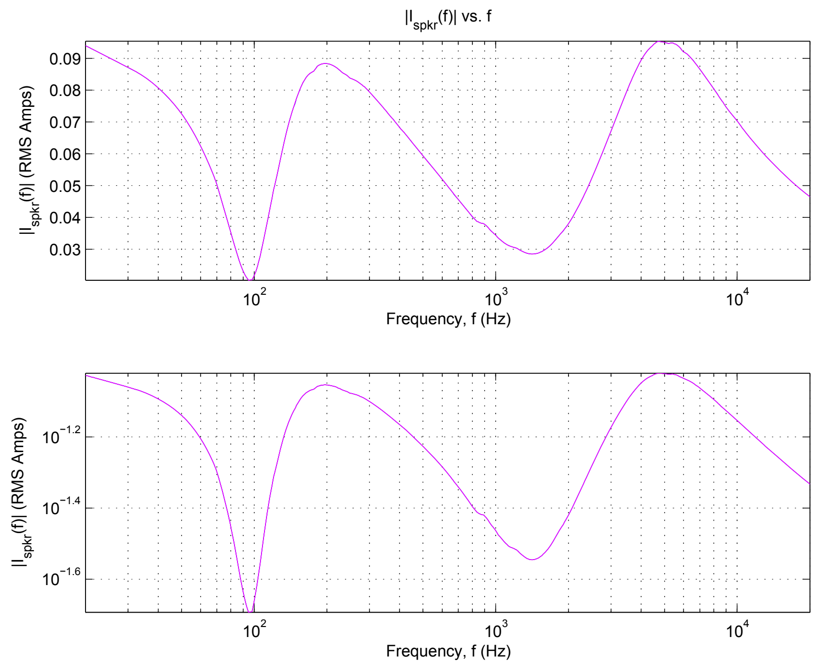

Figure 8: GE – Current Magnitude vs Frequency

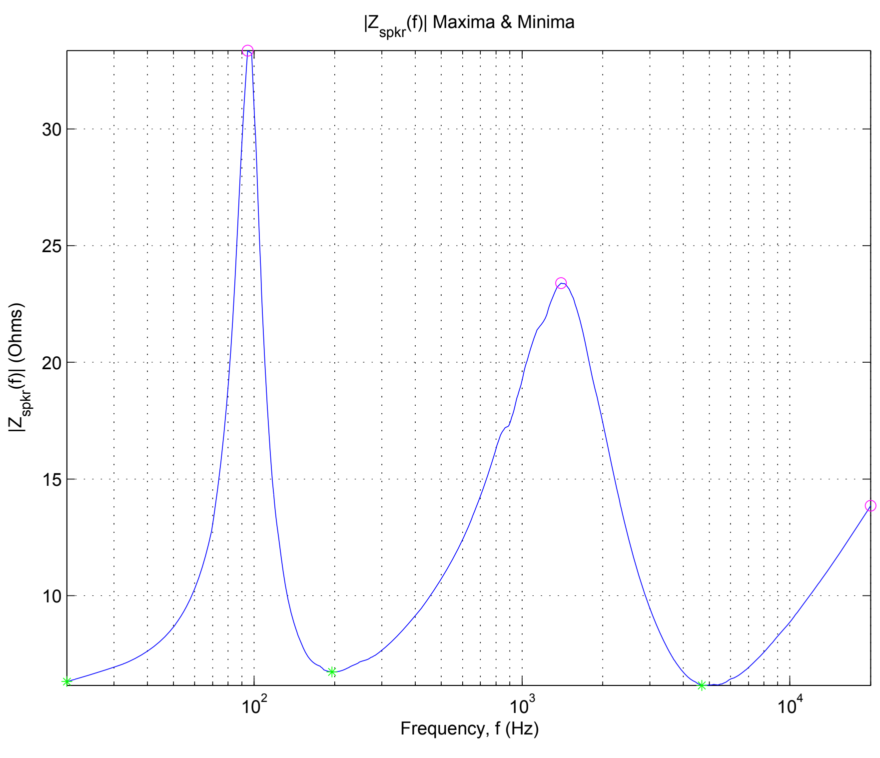

Figure 9: GE – Impedance vs Frequency

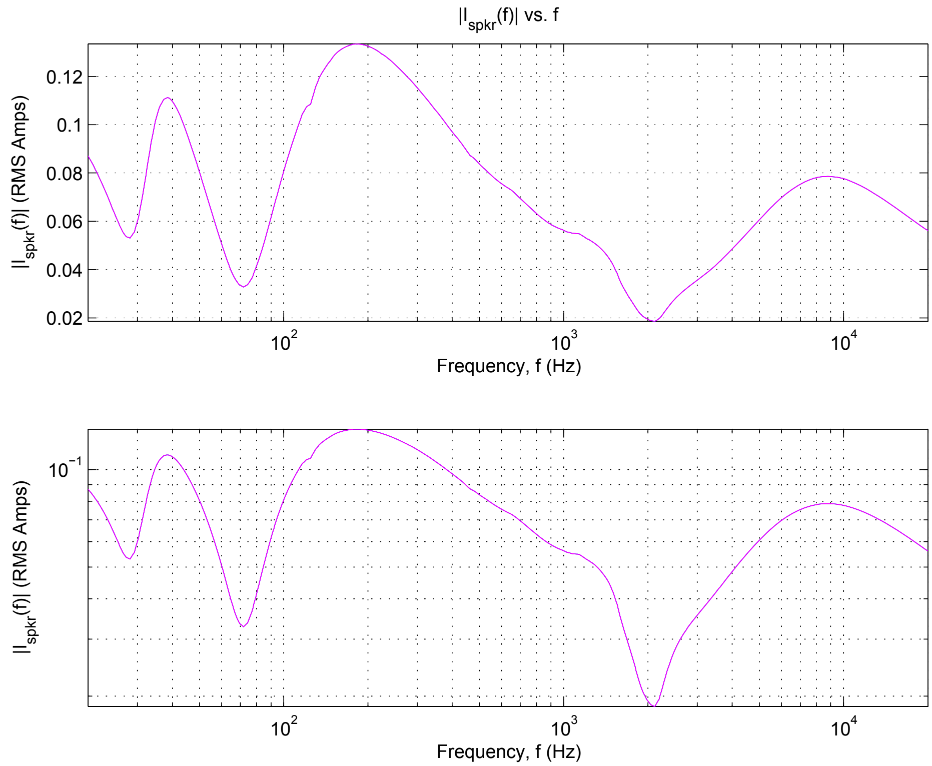

Figure 10: Klipsch – Current Magnitude vs Frequency

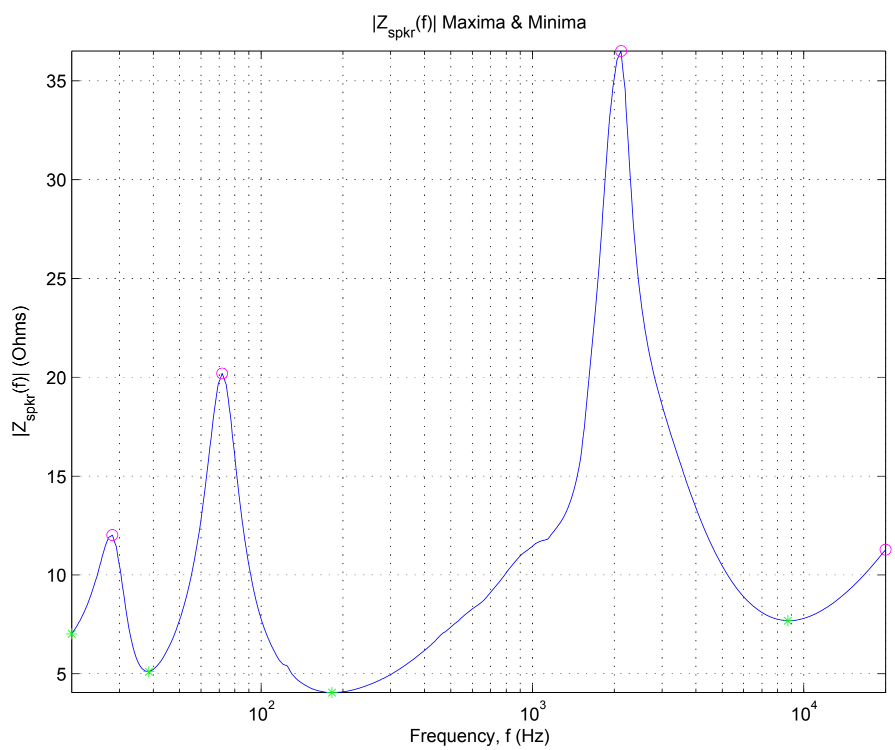

Figure 11: Klipsch – Impedance vs Frequency

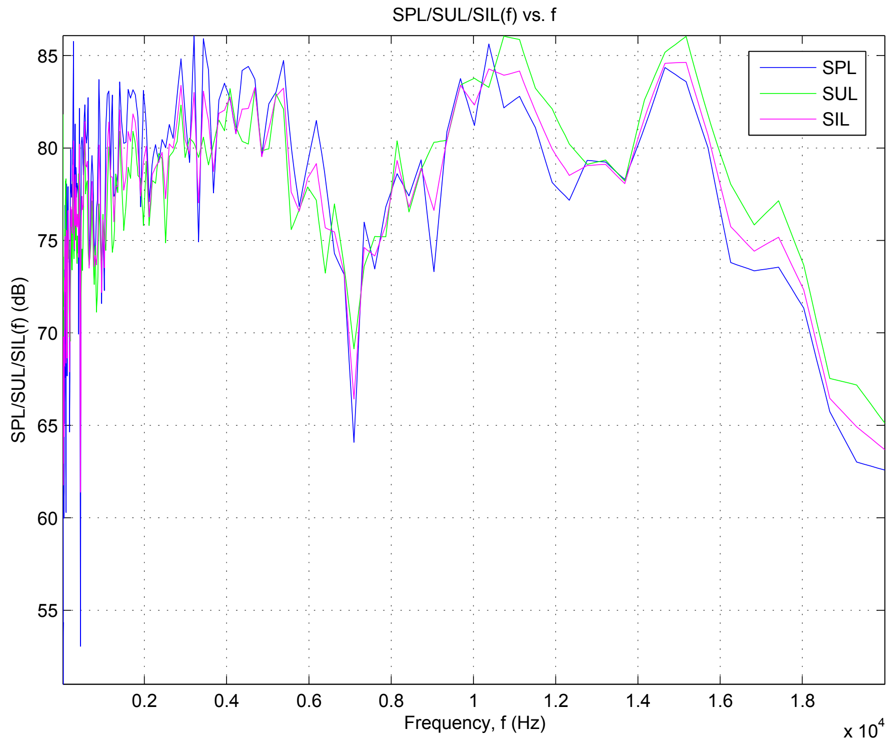

Figure 12: Akai – SPL – SUL – SIL vs Frequency

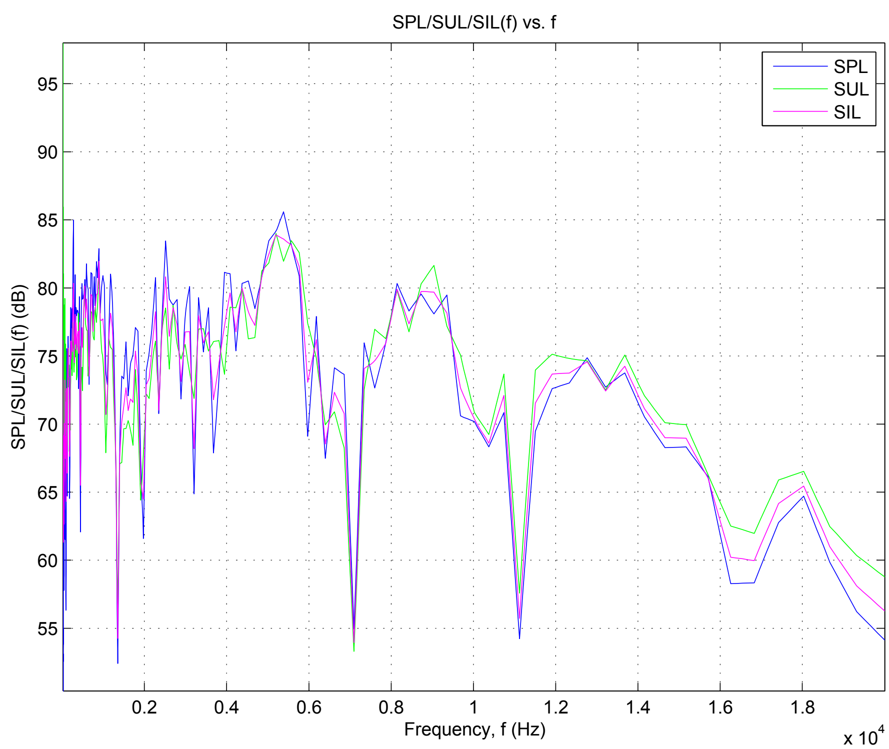

Figure 13: GE – SPL – SUL – SIL vs Frequency

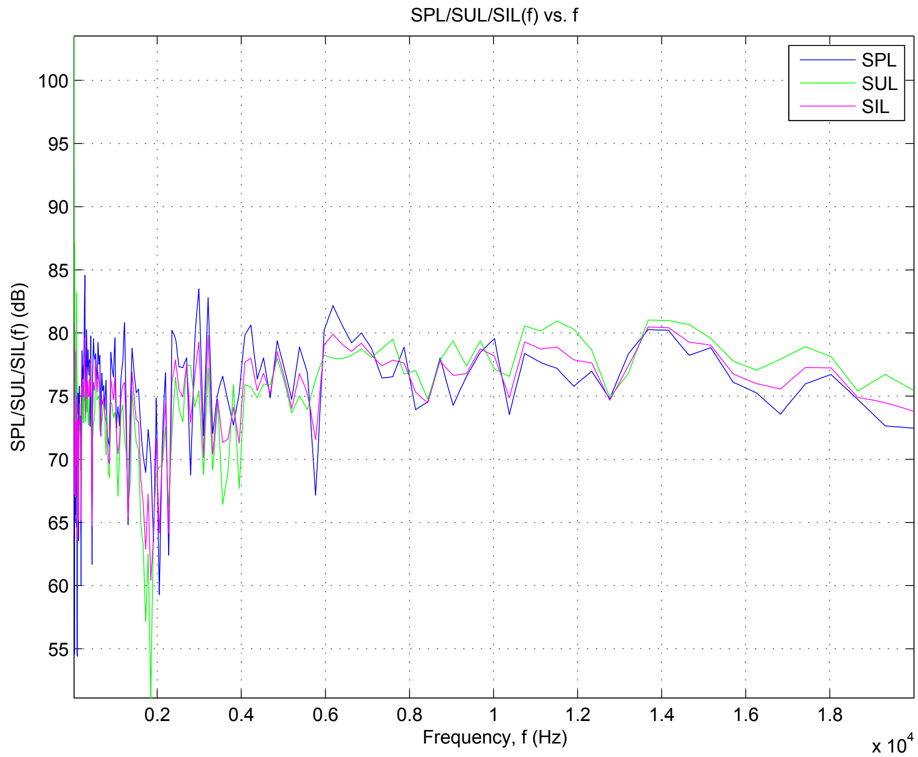

Figure 14: Klipsch - SPL – SUL – SIL vs Frequency

Conclusion

From these plots we can make the conclusion that the Klipsch is the best of these speakers. We can make this conclusion since the response, seen is figure 14, is very consistent in the magnitude of SPL, SUL, and SIL. When you look at both the GE and Akai, their response significantly dies off above the 10 kHz mark. However, for the Klipsch speaker, it stays at a consistent magnitude up to 20 kHz. From this we can conclude that this speaker has the overall best performance of the three speakers. If I had more time I would've liked to have discovered what the cause of the significant dip at 6 kHz was caused by. But for the purpose of this experiment we were able to successfully determine which speaker had the best performance.