Cherry Bomb

Modular Speaker for Office Desktop Monitors or Living Room Tower Speakers

Designed by: Ace Hobbs

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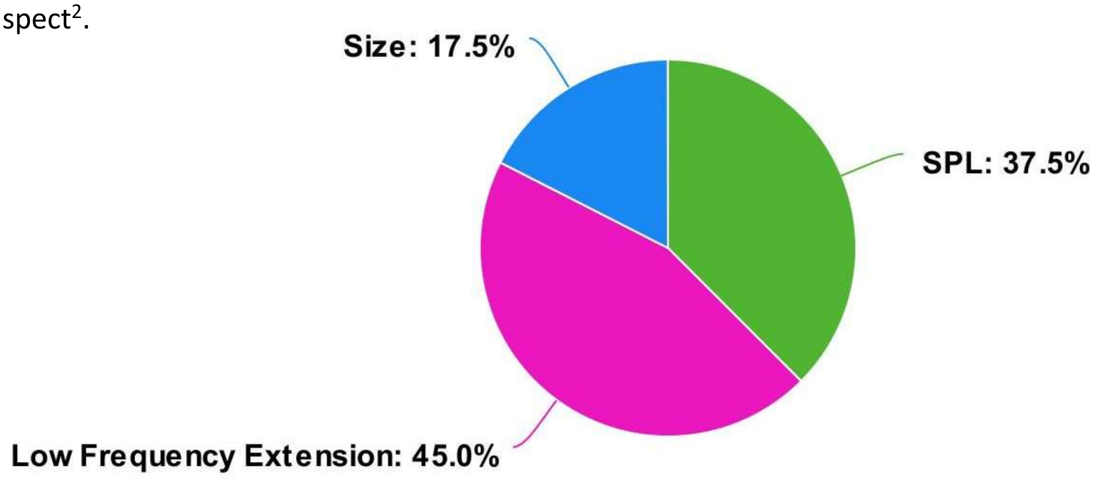
1.0 Functional Description

These speakers will serve as my introduction to the wide world of transducer theory. They will be a hybrid tower speaker with emphasis on a stellar low frequency extension and flat frequency response. The hybrid aspect comes into play between the subwoofer and mid/high components of the speaker, quite literally. The system will technically be a left and right subwoofer component paired with a separate mid/high component which will rest on top of the subwoofer cabinet. The design will be integrated to keep the speaker pair looking sleek and purposeful. This design provides the option to use the mid/high component as desk monitors while also increasing mobility for easier transportation.

These speakers will be used as entertainment speakers placed around a tv in the living room. Their primary function however will be listening forward music playback. While I want them to sound good, a completely true recreation of the recording session is not necessary. Given Moutlon's range rule, the system as a whole can be used as a reference system for a listener who wants any low frequencies in the mix to stand out[1]. These speakers should produce higher levels of SPL for my own personal desires. They will not be expected to reproduce concert level SPL. The listening position will be the mid-field, so directionality of the mid/high component will be critical to avoid as many nasty room reflections as possible.

Size is not a big concern when designing these speakers. That is to say the size will change to accommodate the low frequency extension and SPL I am aiming for.

Below is a pie chart based on John Murphey's three points of design tradeoffs. There is a larger emphasis on the low frequency extension with the SPL following closely behind. These speakers can get as big as needed to fulfill my requirements, so a lesser emphasis has been placed on the size aspect[2].



[1] Moulton, *Total Recording,* 313.

[2] Murphy, *Loudspeaker,* 62.

2.0 Reference Systems

2.1 Overview

A series of tower and bookshelf speakers have been referenced for design considerations regarding this project. These speakers explore the quality range, and price range, while providing data on different sized drivers and different port types. All of the tower speakers analyzed are three-way systems. All of the bookshelf speakers analyzed are two-way systems. The idea behind researching both tower and bookshelf speakers is to get a good idea of how my hybrid system should perform as a whole, and then how the mid/high component should perform individually.

Initially looking at the tower speakers below, the SPL is consistent around 111 dB with one outlier at 98.6 dB and one with no data. The outlier in this group is also a custom cabinet not produced by a manufacturer. The F3 is again similar amongst the group ranging from 35 Hz to 24 Hz with one outlier reaching 52 Hz and one with no data. It is important to note that two of the five tower speakers referenced are custom to the individual and not produced by a manufacturer.

Tower Speaker	F3 (Hz)	SPL Peak (dB)	Weight (lb)	Dimensions (inch)	Price Per Pair (US$)
88man Customs	???	98.6	???	15.25w x 18.5d x 47h	???
Polk MXT70	35	112.1	35	9.25w x 12.5d x 40.4h	558
Totem Wind	24	111	74.8	10.7w x 14d x 44.3h	12,000
Revel F206	52	111.1	58	9.8w x 13.6d x 41.4h	1000
Smooth Smith Audio - 312c	28	???	90+	???	2500

The bookshelf speakers below follow the same trends as the tower speakers above. Something to note is the consistency in the dimensions category. Averaging the dimensions results in 7.7w x 10.7d x 13.9h. Comparing this to Murphey's suggested golden enclosure ratios[3], the width and depth both fall within +/- 1 inch of each other when trying to fit them into a golden ratio. The height in any case is over 4 inches shorter than expected. As long as the dimensions are dissonant from each other it shouldn't be a big deal, but it is certainly interesting.

Bookshelf Speaker	F3 (Hz)	SPL Peak (dB)	Weight (lb)	Dimensions (inch)	Price Per Pair (US$)
Polk Reserve R100	58	107	12.2	6.5w x 10.2d x 12.8h	599
Totem Signature One	45	110	23.1	7.67w x 10.62d x 13.77h	3500
Revel M106	59	108	19	8.3w x 11d x 15h	1,100
Thunder and Lightning	55	???	???	8.5w x 11d x 14h	???

[3] Murphy, *Loudspeaker,* 101.

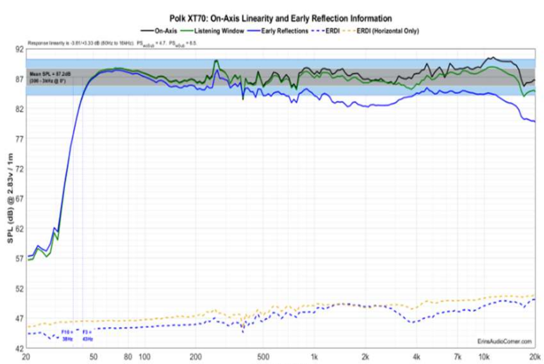
2.2 Tower Loudspeakers

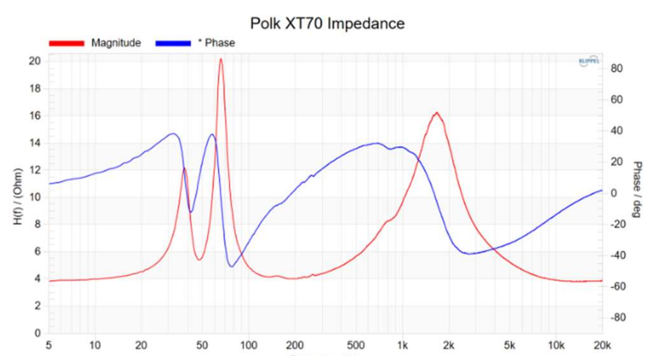
88man Customs[4]

The 88man Customs are an interesting speaker to study. These speakers will reach a max SPL of 98.6 dB SPL. That is the main technical specification available to me given the forum discussion. However, 88man describes his process for treating the speakers. 88man used MDF for the speaker cabinet then applied a layer of cherry veneer to spruce it up. After 14 layers of Arm-R-Seal Oil finish was applied the speakers were complete. The geometry is stunning and beautifully integrated between the two cabinets. There is an air gap between the subwoofer cabinet and mid/high cabinet which I find fascinating. It looks sleek and allows for extra mobility given the cabinets are separate. There is no discussion about the decoupling method used in the separation, but I am assuming by the picture that some type of feet were used.

Polk MXT70[5]

The Polk MXT70's are a great reference speaker for their technical specifications and price point. They achieve an F3 of 35 Hz with a dual 6.5" woofer setup. The kick is that they also utilize dual 8" passive radiators for deeper bass, something I could include in my design. With only three drivers, the MXT70's achieve an SPL peak of 112 dB. The frequency response escapes the desired +/- 1.5 dB, but the price point makes up for this specification. The impedance response is also an interesting point of study. The two peaks in the low end represent the passive radiators and woofers while the peak in the high end represents the tweeter[6].





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[4] https://www.audiocircle.com/index.php?topic=141357.0
[5] https://www.polkaudio.com/on/demandware.static/-/Library-Sites-polk_northamerica_shared/default/dw0e2ee744/downloads/monitor-xt60-xt70-infosheet-en.pdf
[6] https://www.erinsaudiocorner.com/loudspeakers/polk_xt70/

Totem Wind

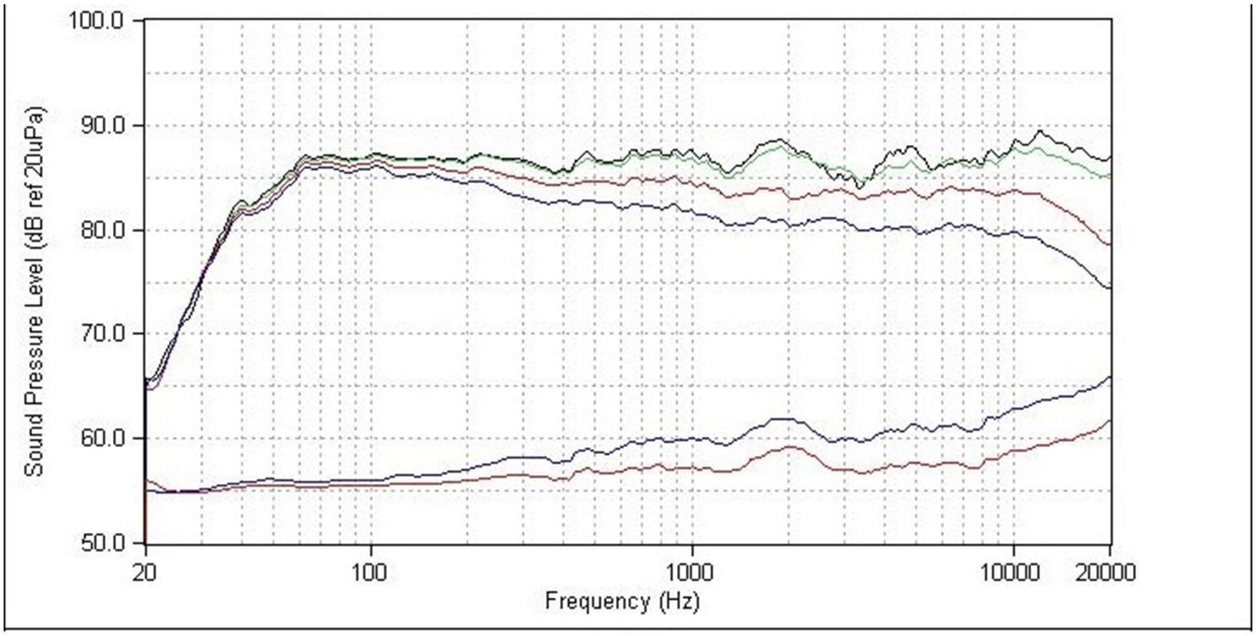
The Totem Wind loudspeakers offer many attractive components. Their design is sleek and clean with a purpose. The complex cabinet geometry aims to eliminate resonance within the box on top of looking great. The proprietary drivers are paired with a custom hard wired passive crossover for complete control over the 3-way system. The Totem Wind's are a good example of delicate engineering across the board. With an F3 of 24 Hz and a max SPL of 111 dB, these loudspeakers are a perfect example of technical specifications to reach for.

Totem also offers a decoupling system to reduce enclosure vibrations. The "Totem Claw"[7], right, has a unique design to break up surface standing waves and control resonance on any surface. I might look to implement a design like this for the mid/high cabinet to help limit resonance between the subwoofer cabinet and the mid/high cabinet.

Revel F206[8]

While the Revel F206 loudspeakers may not have the lowest F3, they thrive in providing low distortion sound across the frequency spectrum. They implement distortion reduction mechanisms that stabilize the flux field during operation which provide low distortion at high SPL. The F206 pair can reach 111 dB SPL, a great level that would provide lots of headroom in living area type applications. The SPL is relatively uniform until reaching the upper echelon of the high frequencies[9]. At 1000 dollars, the F206 pair is aimed at providing quality sound in a cabinet that will hide in plain sight.

[7] https://totemacoustic.com/pdf/manuals/Totem_UserManual.pdf
[8] https://www.revelspeakers.com/products/types/floorstanding/F206-.html
[9] https://www.audiosciencereview.com/forum/index.php?threads/yet-another-revel-f206-thread.18729/



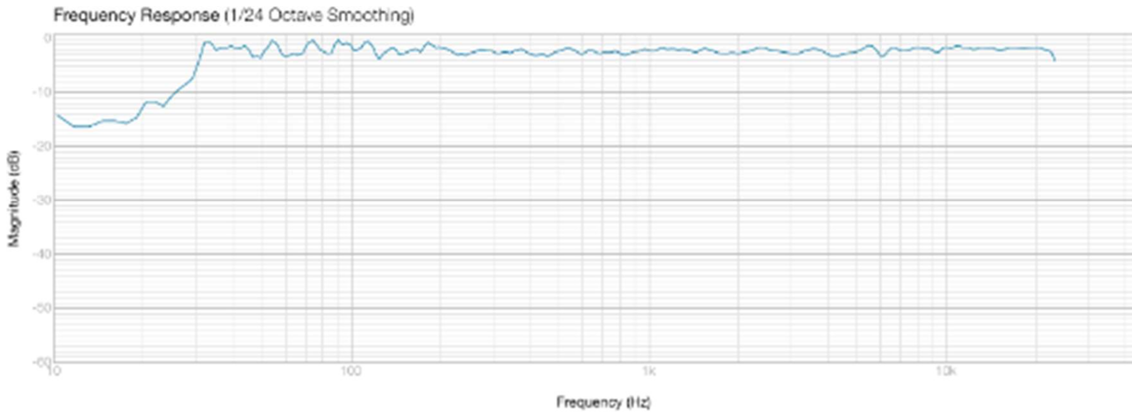
F206

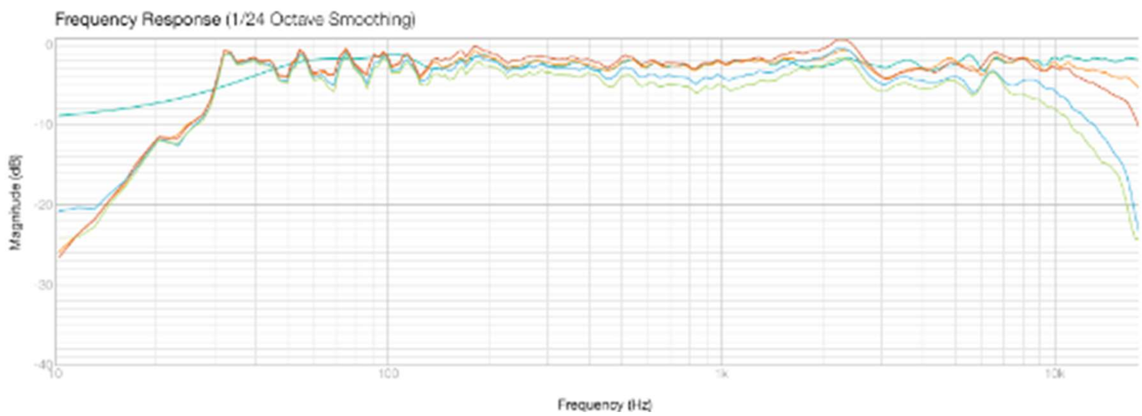
Smooth Smith Audio – 312c[10]

The 312c's from Smooth Smith Audio are a big inspiration for my design. They are the first speaker I saw that advertised themselves as a hybrid design fulfilling two purposes. They look smooth and purposeful with their design. Close attention to detail shines with how beautifully integrated they look when performing as one.

The 312's utilize a 12-inch aluminum cone woofer and a sealed box for the subs producing a desirable F3 of 28 Hz. The frequency response is proficient, landing entirely in the +/- 1.5 dB range. The off-axis response is also inspirational, staying pretty consistent at increasing off-angles.

[10] https://areteaudio.wordpress.com/2017/04/29/smooth-smith-audio-312c/





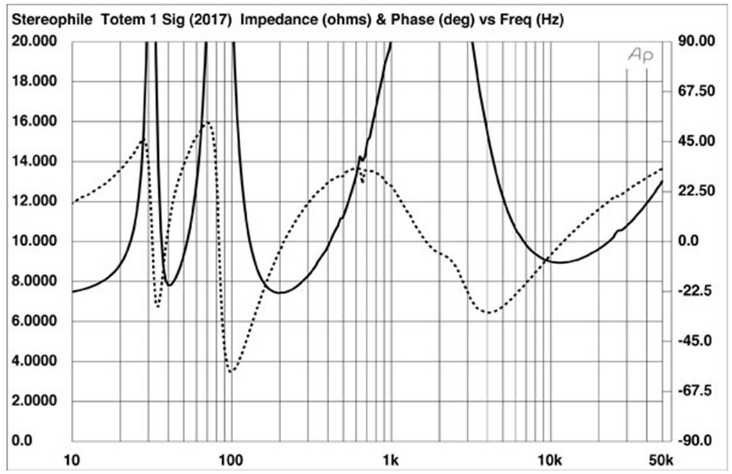
2.3 Bookshelf Loudspeakers

Totem Signature One[11]

The Totem Signature Ones stand out in every category, including their price point. One thing I am particularly interested in is their advertised phase response. The graph below shows the impedance (solid) and phase (dotted) as a function of frequency.

[11] https://totemacoustic.com/product/signature-one/

The phase dips and peaks opposite to the impedance, providing an easy load for the amplifier. This specification is something to aim for when designing the mid/high component of my speakers[12].



Polk Reserve R100[13]

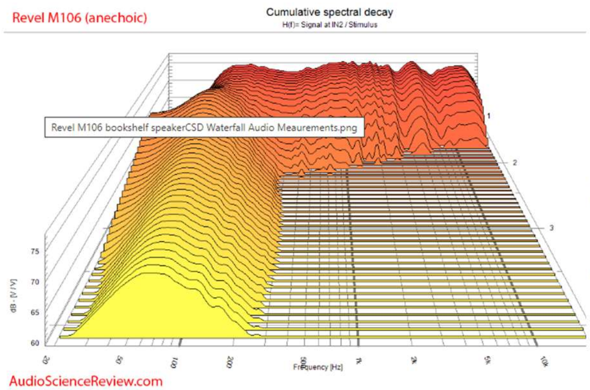
The Polk Reserve R100 speakers implement some interesting technology. They have a ring radiator tweeter which guides the dispersion of high frequencies around the room. This in turn increases the range of listening positions given the high frequencies won't be as directional, however I can see some problems arising at an ideal listening position given the extra room reflections. These speakers have a greater application in stereo or surround situations than backwards listening. They also include a port on the back to extend the low frequency response.

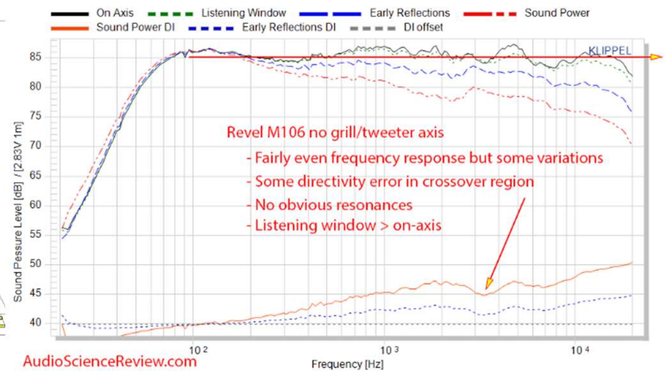
Revel M106[14]

Revel developed new tweeter technology with their proprietary driver. The tweeters dispersion angle very closely matches the low frequency driver's specifically in the crossover region for a fluid transition between drivers. The M106 also implements a low frequency port to minimize dynamic compression, assuring low distortion at bass frequencies. The cabinet features interior

[12] https://www.stereophile.com/content/totem-acoustic-signature-one-loudspeaker-measurements
[13] https://www.polkaudio.com/en-us/product/home-speakers/bookshelf/reserve-r100/300028.html?dwvar_300028_color=Black
[14] https://www.revelspeakers.com/products/types/bookshelf/M106-.html?dwvar_M106-_color=Black-GLOBAL-Current&cgid=bookshelf

bracing that eliminates enclosure-induced coloration. This seems to be successful given the waterfall plot below[15].



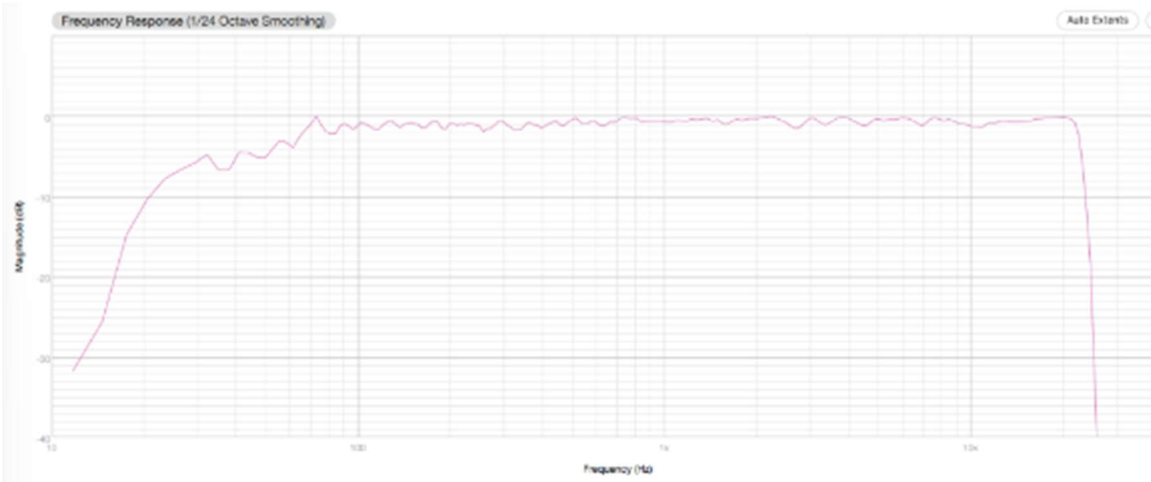


Thunder and Lightning[16]

Thunder and Lightning stick out a little in this category due to their ribbon tweeters. These tweeters provide excellent clarity in the high-end, matching their already gorgeous appearance. The tweeters are paired with ceramic woofers to produce a crisp experience through the mid to high frequency ranges. The enclosures are also sealed to strengthen the transient response. The frequency response is tight, especially when creeping up towards the mid/high frequency range.

Off-Axis response is also tight, even up to 60 degrees. It is important to note that these speakers were paired with a sub to help extend the low frequency. No crossover point was included in the description.

[15] https://www.audiosciencereview.com/forum/index.php?threads/revel-m106-bookshelf-speaker-review.14363/
[16] https://areteaudio.wordpress.com/2019/05/09/thunder-and-lightning/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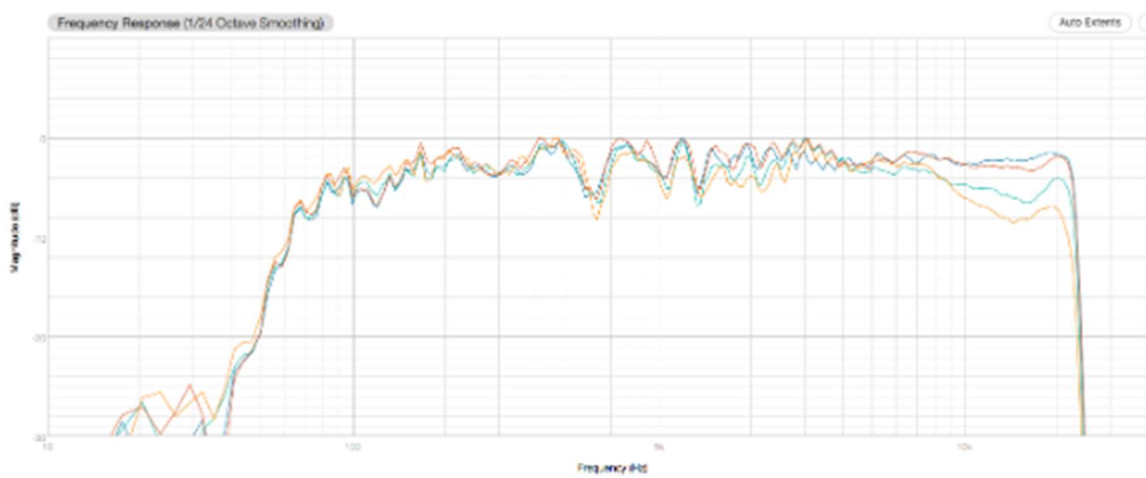
Auto Extents
Magnitude (dB)
Frequency (Hz)


Frequency Response (1/24 Octave Smoothing)
Auto Extents
Magnitude (dB)
Frequency (Hz)

3.0 Technical Specifications

3.1 Sound Pressure Level Testing – Desk Monitors

An important technical specification to consider is Sound Pressure Level. How loud will these speakers need to be? I had some ideas in mind at the beginning of the design process, but these ideas rapidly changed after performing some testing and collecting data. Figure 1 shows Sound Pressure Level readings taken over the course of one week at various times during the day. These levels were taken on a stereo pair of single full range driver speakers that were made my first semester of the Audio Program at Michigan Technological University. The drivers are 3.5 inches in diameter. These speakers were placed on a desk in a small room, usually listened to at an off-axis angle while preparing dinner or breakfast. The platform of listening was Spotify, so 14 dB peaks can be added to these averages for the crest factor.

At the end of the week I came away with one result, they sounded great. The volume was comfortable to the ears and pushing the level higher introduced an uncomfortable listening experience. I thought a comfortable listening level was around 80 dBA SPL, however my experiments led me to believe that 65 to 70 was much more desirable in this situation. Further data was collected to test this theory.

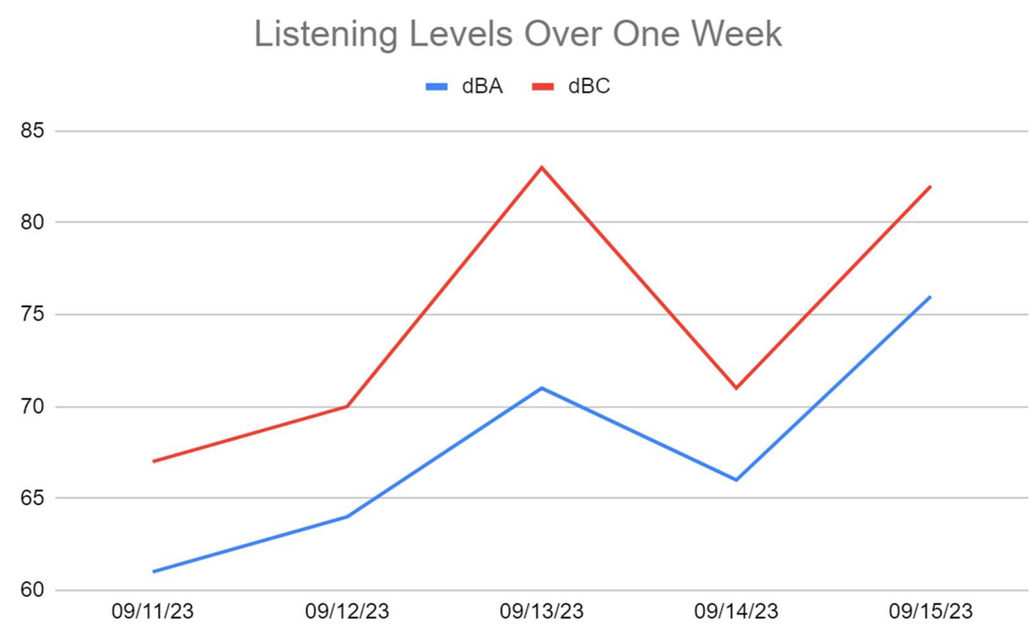


Figure 1 - lisening levels taken at a comfortable level to me over the span of one week.

3.2 Sound Pressure Level Testing – Urei Model 813

Following this week of listening I wanted to compare these data points to my initial ideas for listening level. While this isn't a sustained listening level, I wanted these speakers to be able to play at an average of 95-100 dBA SPL. I tested louder levels on two separate systems. The first was a stereo pair of Urei Model 813 Monitors installed with a Model 839 Control Panel. The speaker is a two-way system consisting of a 15-inch woofer paired with a horn loaded higher frequency driver. They comfortably reproduced levels up to 90 dBA SPL[17]. Figure 3 shows the dBA and dBC levels of 20 songs at a consistent level around 90 dB on Apple Music. +16 dB should be considered for the crest factor of these averages These songs include 12 bass heavy rap songs, 3 acoustic songs, 2 industrial rap songs and 3 electronic songs.

I liked what I heard. This level was much louder than I expected and fatigued my hearing overtime, but for a couple minutes of listening it was fun to play some loud music. I didn't find the bass response to be too impressive, but the room was also rather large and there were no boundary effects taking place[18]. Overall, I liked the sound, however there is some room to make up in the low frequency response. These results correspond with the conclusion I came to in section 3.1, the levels I am looking for lie closer to the 70 dBA range.

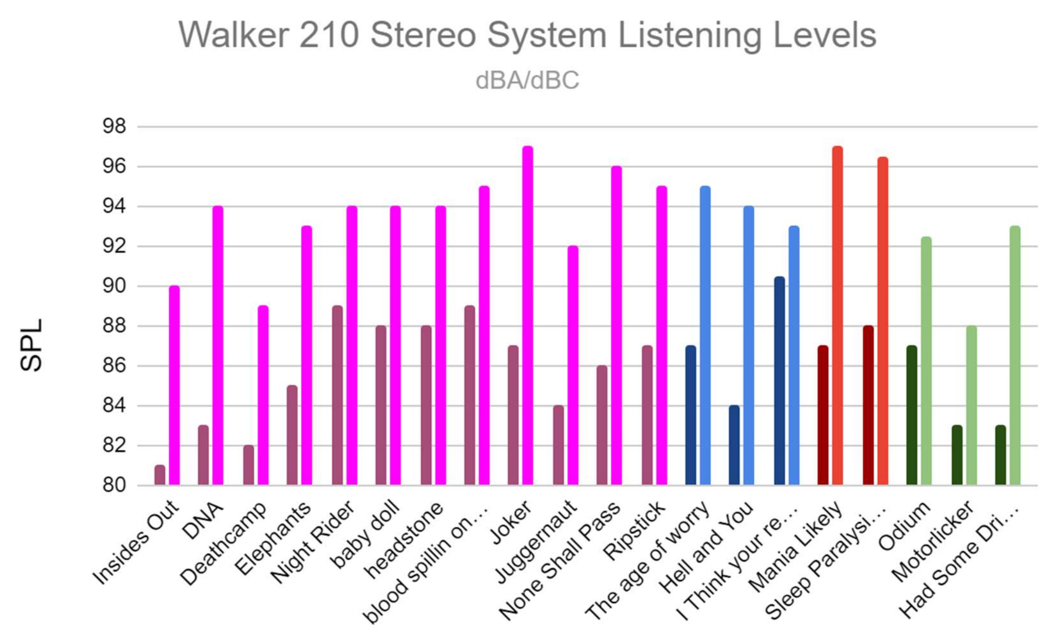


Figure 2 - listening levels of the Yuri Monitors in one of Michigan Tech's classrooms.

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[17] http://bee.mif.pg.gda.pl/ciasteczkowypotwor/%23pro_audio/Studio/UREI-813A.pdf

[18] Newell, *Loudspeakers*, 203

3.3 Sound Pressure Level Testing – Bass Junkie System

I then ventured over to my fraternity house where I have a killer bass junkie system. This system consists of two dual 18 inch subwoofers and a JBL mid/high tower speaker. I listened to the same 20 songs in the same order at levels closer to an average of 95 dBA SPL, this time on Spotify. +14 dB should be considered for the crest factor of these averages. The room in which my bass system lives is larger than the space the Urei Monitors live, allowing the subwoofers to reach their full potential. I knew I could push this system harder than the school system given it is my own, so it provided me with great data. Figure 3 shows the results of the listening experiment. Initial things to note are the differences in average levels between the two systems and streaming services. Room size, streaming service, and speakers are all factors to these level differences. But that is not critically important. The important part is my subjective enjoyment of the loudness considering all of these differences. The bass was incredible, it shook the whole building and almost dropped some ceiling tiles from the drop ceiling. The mid/high frequencies don't share the same qualities. They were harsh and overall just way too loud. While the bass was incredible it didn't allow for an extended listening session. My hearing was fatigued a couple of songs in due to the high SPL and harsh higher frequencies. This is to say, listening to these levels at a concert is a great experience but largely unnecessary in a home system. I can't think of many situations where this level of SPL is required, even if I want to bump some bass[19]. A smaller room and the boundary effect of a corner would provide me with the desired low frequency response if I aim for moderate SPL.

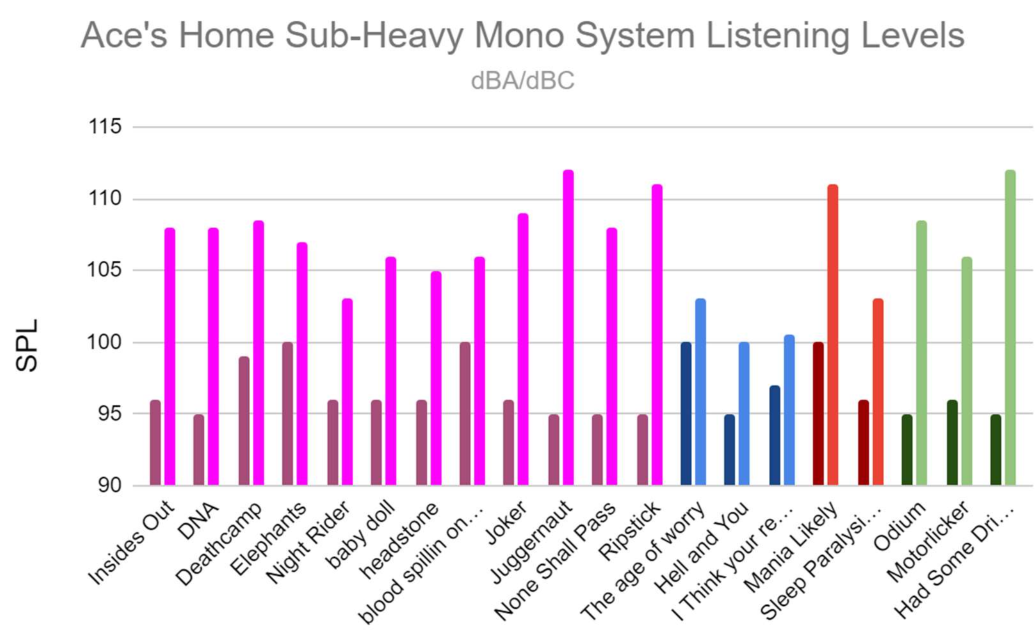

Figure 3 - listening levels of my custom system consisting of dual 18 inch subwoofers and a JBL mid/high tower speaker.

[19] Newell, *Loudspeakers,* 206.

3.4 Sound Pressure Level Testing – Conclusion

Based on these experiments I have a better understanding of SPL and what is a comfortable listening level. My initial desires of 95 dBA SPL were just ridiculous, but you have to learn somehow. The lab we were assigned that made me jump into these experiments certainly succeeded in its purpose, help the sound students understand what loud is. The clarity and gentle hug the lower listening levels gave my ears generated a greater emotional response within myself than sound pounding my eardrums as I hoped the ceiling wouldn't fall apart. Christopher Plummer also told me something when I talked to him about this data that stuck with me. He reminded me that movie theatres are tuned to 83 dBA SPL, and theatres are pretty loud. Thinking about being in the theatres would give me a good reference for the rest of my design considerations.

3.5 The K-System and New Design Philosophy

Bob Katz wrote about the K-System in the 1990's before the development of the loudness unit LUFS. The K-System is a way for sound engineers to calibrate their systems in such a way that standardizes the levels they work at when mixing and mastering music. The idea is that 83 dBA SPL is the 0 mark on our meters. Past 83 dBA SPL we leave some space for headroom depending upon what is being mixed. Film should have 20 dBA of headroom, most music should have 14 dBA of headroom, and broadcast should have 12 dBA of headroom. These values come in under 0 dB FS, the goal being to never reach 0 dB FS[20]. One of the most important concepts from this conversation was a listening test Katz conducted at an AES conference. Among about 1000 audio engineers, 83 dBA was determined to be a comfortable listening level. This is 12 dBA under the level that I was initially considering and much higher than the results of my listening experiments. Some things to note are that the individuals were sat in a large conference room far away from the sound system, rather than being in a living room within close proximity to the speakers. Comparing this opinion to my own after the listening experiments discussed in sections 3.1-3.4, I have a new design philosophy. If 83 dBA can be considered a comfortable listening level at a distance, I don't need to aim nearly as high as I had initially thought. Crest factor should also be considered given the advent of streaming services as the dominant playback option. Netflix has a large LUFS value coming in at -27 LUFS. All streaming services I have encountered do not reach -27 LUFS and would have safe crest factors if -27 LUFS is accounted for. If I aim for a peak SPL output of 95 dBA SPL, I would be at a listening level of 68 dBA average. In a living room within close proximity of the speakers, that is still plenty loud.

3.6 Listening Distance

The experiments performed in sections 3.1-3.4 were conducted from a listening position of 4 meters away from the center point of the stereo image. Given that these speakers are going to

[20] https://www.digido.com/portfolio-item/level-practices-part-2/

be used in a living room setup, this seems like an appropriate listening distance to base my designs off of. If I am aiming for a total SPL of 95 dBA at a listening position of 4 meters, I would need to add 6 dB to accommodate for the 4 meter distance. This places me at 101 dBA from the drivers themselves to satisfy my requirements. This is an overestimation based on a pretty large listening distance, but the extra headroom won't hurt.

3.7 Amplifier Specifications

I will be using three amplifiers in this system to power the subwoofers and mid-highs separately.

The subwoofers will be powered with a QSC MX3000a which I came into possession of during an internship. This amplifier allows for 1200 Watts per channel at 4 Ohms. Using the dBw conversion equation with 1200 Watts, the added SPL is about 30 dBw[21].

The mid/high components will be powered with their own Fosi Audio V3 which I will purchase. This amplifier allows for 300 Watts per channel at 4 Ohms. Using the dBw conversion equation at 300 Watts, the added SPL is about 24 dBw.

3.8 Desired Sound Pressure Level

Based on section 3.6, my desired peak SPL is 101 dBA at 1 meter. I will have two sensitivities to present given that the subwoofers and mid/highs are two separate cabinets.

Based on the above statements and dBW calculations from section 3.7, my best subwoofer sensitivity would be 71 dB @ 1W/1m. That is my best outcome goal, but to keep things realistic I will be incrementing 3 dB losses as marks of success. This means that 68 dB would be my great outcome level, and 65 dB would be my good outcome level.

My best mid/high sensitivity would be 77 dB @ 1W/1m. My great outcome level would be 74 dB, and my good outcome level would be 71 dB.

[21] Plummer, 09/18/2023

4.0 Cabinet Design

4.1 Visual Design

My cabinet design is inspired heavily from the 88man Customs and the 312c's. Its modular design will help with portability while also allowing me to use the two components separately. The mid/high cabinet will sit on top of the subwoofer cabinet. I will be putting rubber feet on the mid/high cabinet to keep it in place in case something bumps into it. I will be aiming for a 15-18" subwoofer to supply my goal for a better low frequency extension. I will be aiming for a 6.5-8" midrange woofer to crossover nicely with both the subwoofer and tweeter. Contrary to what is drawn in the picture, I will be aiming to use a dome tweeter to crossover with the midrange woofer.

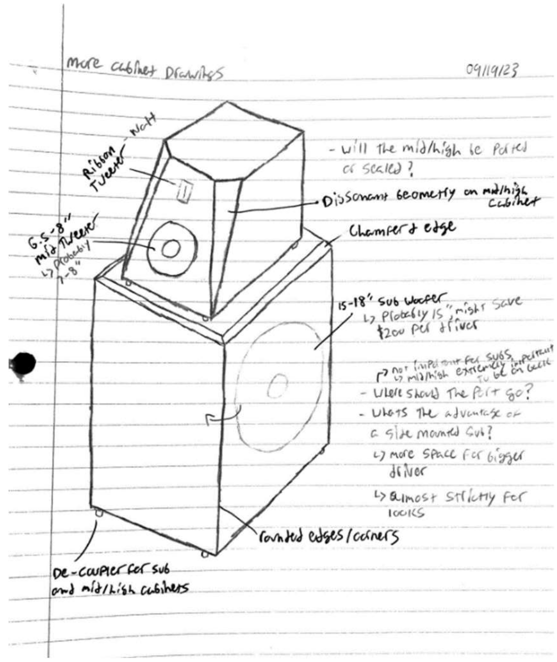

Figure 4 - Initial cabinet designs as of September 19, 2023

4.2 Listening Axis

I took some measurements of my ear height from the floor in preparation for this section. The terms used to describe the sitting positions are rather subjective, but they will work for the purposes of this paper.

- Ground Seating: 30.5"
- Low Chair: 45.5"
- Medium Chair: 50.5"
- High Chair: 60"
- Standing: 65"

As these speakers are going to be placed in a living room around a tv, it can be assumed people will be sitting on couches away from the speakers. The listening height between low and medium will most likely work out in my favor. It should also be noted that good off axis response is not critical but would certainly benefit the people sitting on the off axis.

4.3 Cabinet Dimensions

Based on preliminary woofer modeling (Refer to Appendix A and section 6.0), I have determined that a subwoofer cabinet with an internal volume of about 8 cubic feet would help me achieve my design goals. Applying this internal volume to Figure 4, I can deduce the general dimensions: 19"w x 20.25"d x 36"h. I would like to have the subwoofer cabinet around 3 feet tall. This would provide a good listening height for the overall system given the mid/high component will rest on top of it. I do recognize that the width and depth dimensions are close together, but as long as I keep things dissonant this shouldn't be a problem (especially in the subwoofer cabinet).

The mid/high component will be designed to fit nicely on top of the subwoofer cabinet. Based on the reference systems in section 2.1, I can deduce that a decent volume would measure around 1 cubic foot. This size would also help the cabinet look proportional to the subwoofer Here are some preliminary dimensions without any driver modeling applied to the design process: 9"w x 10"d x 13.5"h.

It is important to note that these are the internal dimensions. If I plan to use 3/4 inch thick MDF for the cabinet material, 1.5 inches will be added to the width, depth and height to accurately describe the external size. I will also be putting feet on both boxes for de-coupling, so another two inches can be added to the overall height to account for those.

4.4 Cabinet Modeling

I first took to modeling my cabinets based on my predicted measurements given in 4.3. I modeled the cabinets in Autodesk Fusion360[22]. I altered my preliminary dimensions for the mid/high cabinet based on driver size and internal volume considerations. These dimensions ended up being 10.125"w x 14.375"d x 16"h. Figure 5 shows a cut view of the subwoofer cabinet. Some things to note are the layers of internal bracing spanning the bottom of the cabinet to the top of the cabinet. This internal bracing was designed to help increase box rigidity and decrease overall cabinet resonances. Using plywood for the bracing would help given plywood's natural resistance to movement across the grain and the two materials would dampen each other. The same idea was implemented for the mid/high cabinet which can be seen in Figure 6. Less internal bracing was implemented given the reduced size of the cabinet. The subwoofer also features a 4 inch front facing port while the mid/high cabinet features a 2 inch rear facing port. Both cabinets use an NL4 connector as input into the cabinet. The mid/high component has the tweeters wired to the 2 pins while the woofers are on the 1 pins.

[22] https://www.autodesk.com/products/fusion-360/personal

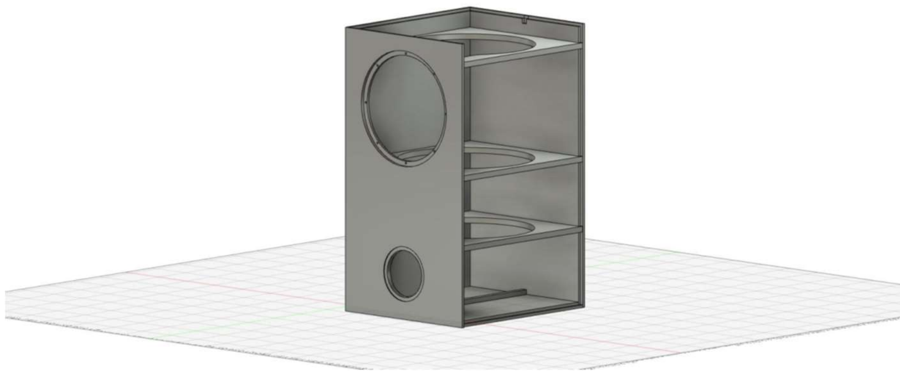

Figure 5 - cut view of subwoofer cabinet

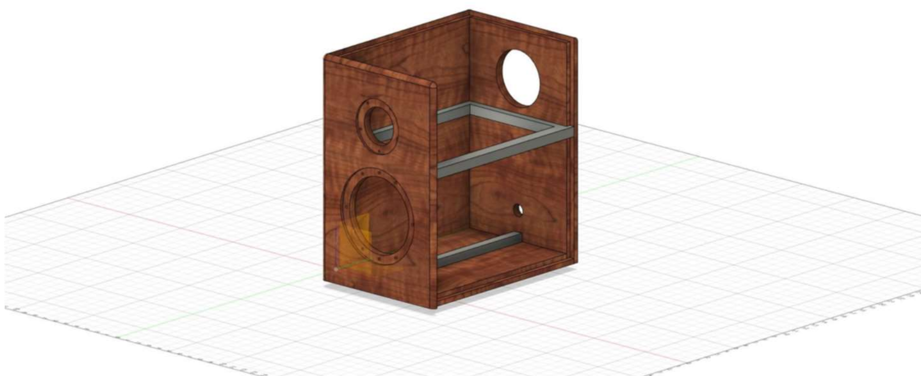

Figure 6 - cut view of mid/high cabinet

4.5 Cabinet Drafting

After my cabinet was modeled, I got to drafting. I pulled all important dimensions from the model and transferred them to 2D drawings of every face and support piece. I drafted these faces in Vectorworks[23]. The draft packet ended up being 15 pages long and helped tremendously during the physical build process. An example of the front subwoofer face can be seen in Figure 7. I also drafted cut plans on 4x8 boards to predict how each piece would be cut out of the purchased material. This helped me make sure everything fit and that all pieces were accounted for.

[23] https://www.vectorworks.net/en-US

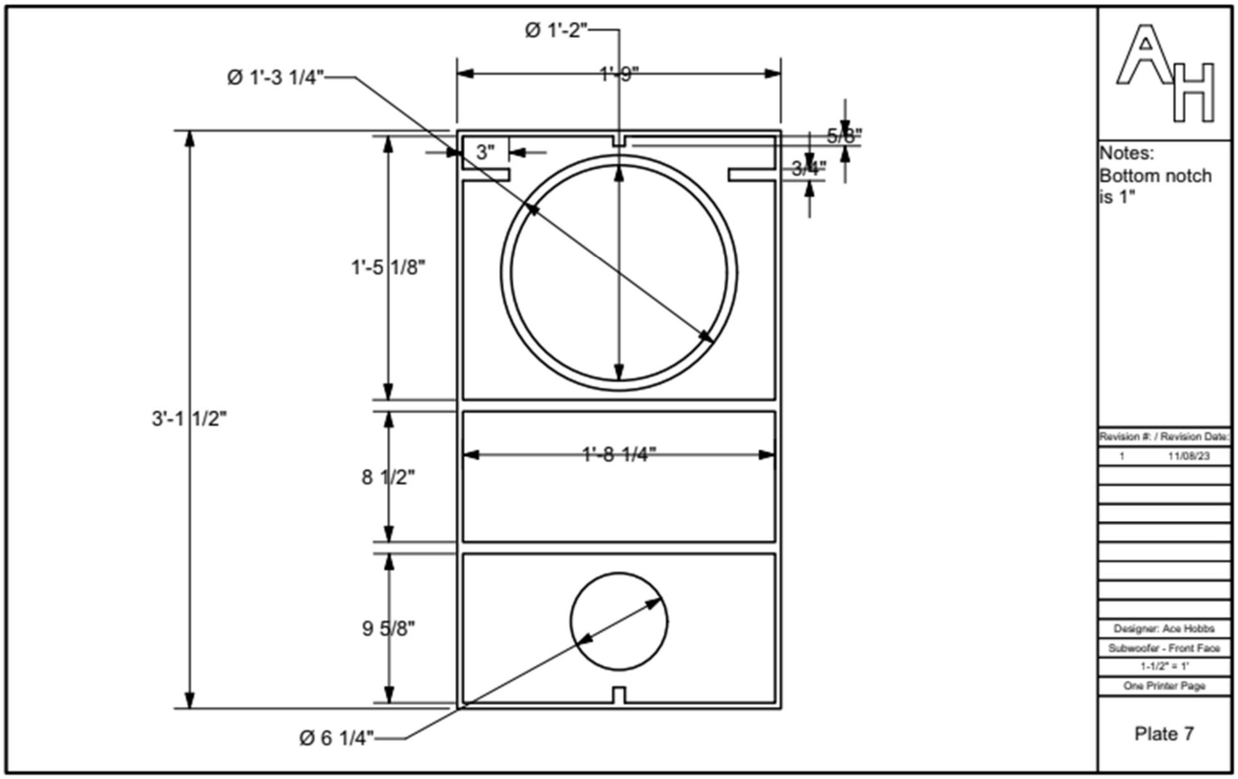

Figure 7 - Vectorworks draft of the front face of the subwoofer cabinet

5.0 Tweeters

5.1 Scan-Speak Discovery D2606/9200[24]

The Scan-Speak Discovery D2606/9200 is a very desirable tweeter for my speaker design. The Discovery family tweeters feature fabric diaphragms with either traditional domes or ring radiators. In this instance, we have the classic dome design.

The sensitivity of the tweeter clocks in at 91.5 dB, which will pair nicely with the selection of woofers I am considering.

The off-axis response leaves a lot to be desired. At 10K Hz, the 60 degree off-axis response is over 20 dB down from the on-axis response. While I am not designing these speakers solely for great coverage, this is disappointing.

The on-axis frequency response makes a great case for this tweeter given the off-axis response. With a variance of +/- 1.5 dB across the usable frequency range, this tweeter will pair nicely

[24] https://www.scan-speak.dk/product/d2606-920000/

with any woofer I can match it with. The natural second order roll-off will make the crossover design simpler, allowing for less components and overall, less power loss.

The impedance response seems to be relatively smooth, but it could be smoother. There are some small bumps along the road leading up to 10K Hz. This shouldn't be too big of an issue.

Aesthetically the tweeters are fine. They aren't very extravagant, but I am not looking to draw attention to the tweeters specifically. The classic design will fit in nicely with the rest of the design.

Figure 8 shows the frequency response graph provided by the company with some notes on it pointing out key technical specifications discussed above.

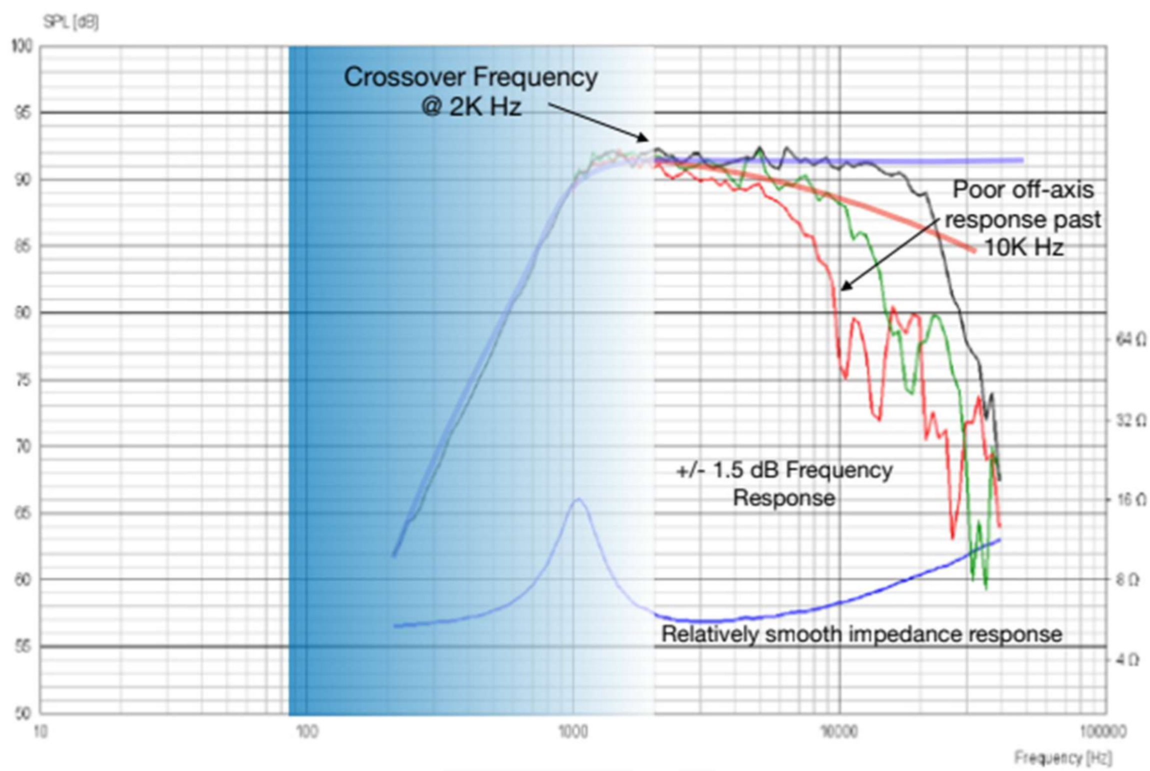

Figure 8 - Frequency response of the Scan-Speak Discovery D2606/9200

5.2 Scan-Speak Discovery D2604/8300[25]

Another tweeter from the Discovery series piqued my interest based on the price point and slightly different technical characteristics.

The sensitivity is 92 dB, just a little louder than the model in section 5.1.

[25] https://www.scan-speak.dk/product/d2604-830000/

The off-axis response seems to be sub-par along this family of tweeters. At 10K Hz, the off-axis response is 20 dB down from the on-axis response.

The on-axis response is also a little scary. The variance of this tweeter is +/- 2 dB on-axis with a huge spike right before 20K Hz. While the frequency response looks desirable up until that point, some serious eq would need to be implemented to get that response under control. There is a natural first order roll off inherent to the tweeter which would help implement a second order crossover.

The impedance response seems to be a little smoother with no noticeable bumps after the resonant frequency.

Figure 9 shows the company provided frequency response graph with notes on the technical specifications discussed above.

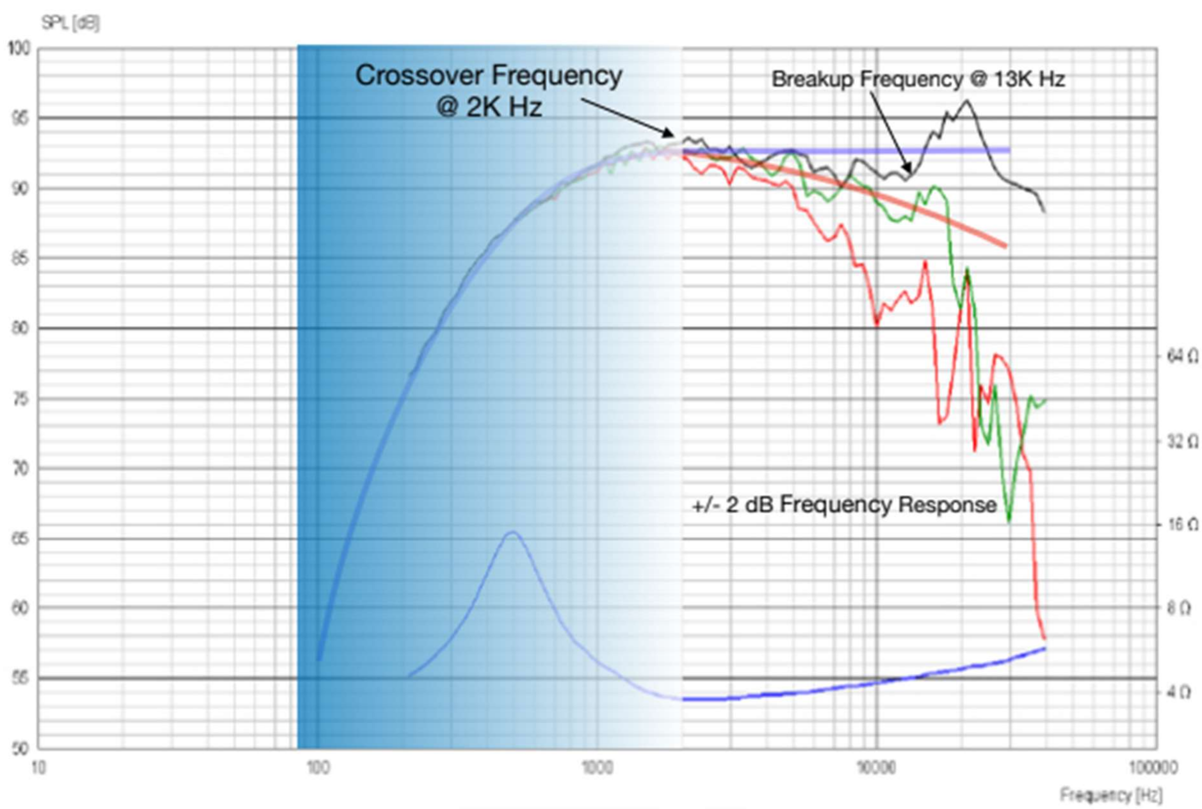

Figure 9 - Frequency response of the Scan-Speak Discovery D2604/8300

5.3 Seas Prestige 19TFF1[26]

The Seas Prestige series of tweeters is dedicated to "The Art of Sound Perfection" for an affordable cost.

The sensitivity of this tweeter is a tad low, clocking in at 88 dB. This would require careful attention when tuning the speaker as the woofer might overpower the tweeter.

The off-axis response is great on this tweeter. At 10K Hz, there is only a 6 dB difference at the farther off-axis angle provided on the frequency response graph (note that I could not find any indicators to the angles of off-axis shown in this graph).

The on-axis response is also stellar with a +/- 1 dB variance on the driver past 20K Hz. The resonant frequency is a little higher, but not too high for a crossover at 2500 Hz. The driver also has a natural first order roll off which would integrate nicely into a second order crossover.

The impedance response is very smooth along its path with no noticeable bumps.

Figure 10 shows the company provided frequency response graph with added notes on important technical specifications.

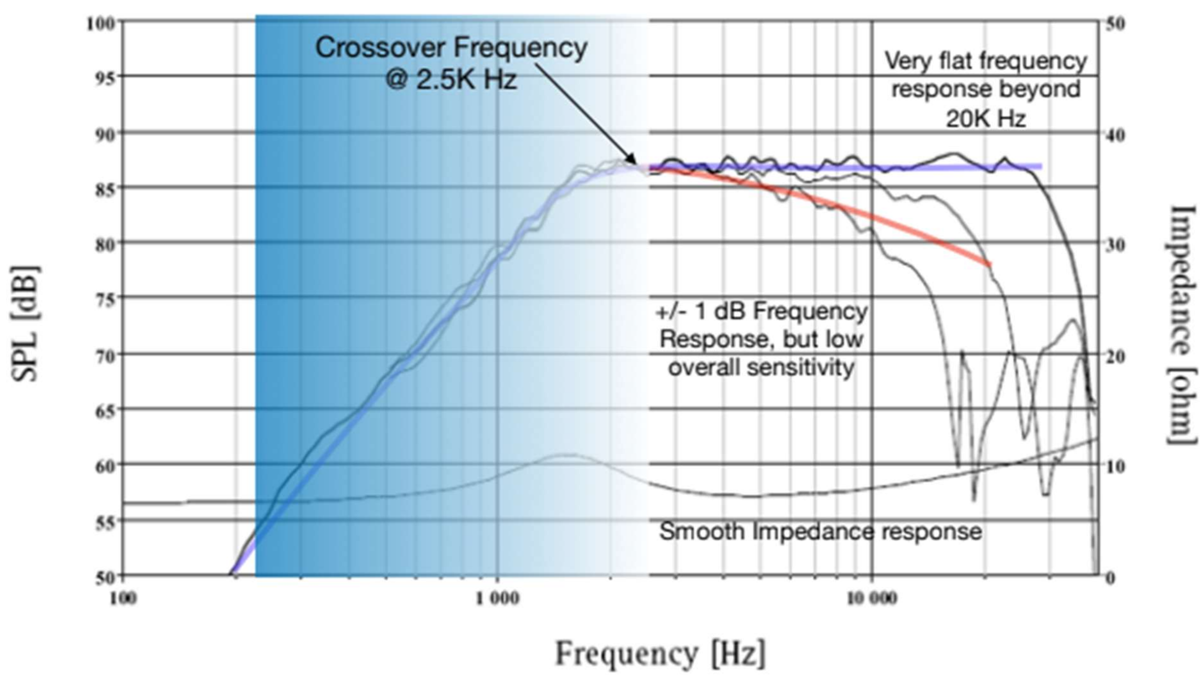

Figure 10 - Frequency response of the Seas Prestige 19TFF1

[26] https://www.seas.no/index.php?option=com_content&view=article&id=50:h0737-08-19tff-1&catid=45&Itemid=239

6.0 Woofers

Section 6.0 discusses the mid-range woofers considered for purchase. Each driver was modeled in WinSpeakerz[27], a program developed by John L. Murphey to accurately predict low frequency interactions between the driver and enclosure. This program also gives you useful information regarding internal cabinet volume and port diameter/length. Refer to Appendix A for the modeling data that is discussed throughout. Figure 11 below has also been included for quick reference of some important specifications: F3, SPL, and price.

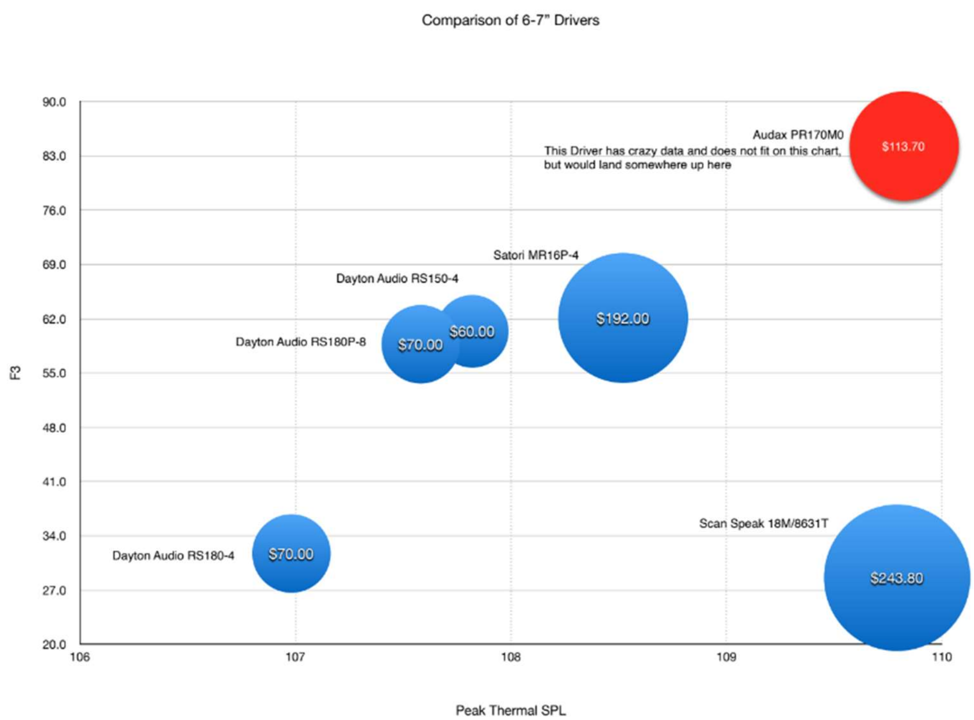

Figure 11 - comparison of F3, SPL, and price of mid-frequency drivers

6.1 Dayton Audio RS225-4A[28]

The Dayton Audio RS225-4A is an 8" paper woofer that excels as midrange/midbass. It is capable of handling 80 watts of power. With a sensitivity of 91 dB, this driver is capable of making some serious noise. Upon modeling this driver in WinSpeakerz, I learned some useful things about its low frequency performance. With an extended low shelf this driver is capable of producing frequencies as low as 45 Hz at 107 dB. While this low frequency extension is desired, I am implementing a subwoofer into the system, so it isn't necessary to scrape the bottom echelon of frequencies with my woofer.

[27] https://trueaudio.com/win_abt1.htm
[28] https://www.daytonaudio.com/product/1226/rs225p-4a-8-reference-paper-woofer-4-ohm

6.2 Dayton Audio RS180-4[29]

The Dayton Audio RS180-4 is a very desirable driver for me. It features an aluminum cone for increased cone rigidity and also an aluminum phase plug to help direct the higher frequencies away from the driver. Aesthetically speaking this driver is beautiful, the all black design and aluminum cones offer a look that I like. The drivers are rather invisible until certain light gleams off of them showing off their metallic finish. This driver also solves some of my frequency problems. With a squared roll off at 50 Hz and the high frequency extension to 3000 Hz, this driver would be able to effectively crossover with both my subwoofer and tweeter while also being able to operate at a desirable internal volume for construction purposes. The aluminum cone allows this driver to produce crisp low frequencies which helps my design goal of great low frequency extension. This driver would also be nice given its sensitivity. I want my tweeter to have a higher sensitivity to inevitably help with system tuning and matching loudness. The 89 dB sensitivity of this woofer will pair nicely with a higher sensitivity tweeter.

6.3 Dayton Audio RS150-4[30]

The Dayton Audio RS150-4 is a similar driver to the RS180-4 sharing many properties, other than their size. This driver has a 6 inch nominal diameter which will limit its low frequency response. In return it will be capable of extending higher into the upper frequencies to take some load off of my tweeter. This driver also features an aluminum cone with an aluminum phase plug matching the aesthetics of the RS180-4. Unfortunately, it has a high sensitivity clocking in at 91.8 dB which will make tweeter pairing a little more difficult. This driver will also be too small to accommodate my desired cabinet dimensions.

7.0 Subwoofers

Similar to section 6.0, section 7.0 discusses possible subwoofers considered for purchase. The subwoofers were also modeled in WinSpeakerz for accurate low frequency interactions with the cabinet. Cabinet volume, port size and length were also gathered from this modeling. Refer to Appendix A for subwoofer modeling data that is discussed throughout. Figure 12 below has also been included for quick reference of some important specifications: F3, SPL, and price.

[29] https://www.daytonaudio.com/product/100/rs180-4-7-reference-woofer-4-ohm
[30] https://www.daytonaudio.com/product/97/rs150-4-6-reference-woofer-4-ohm

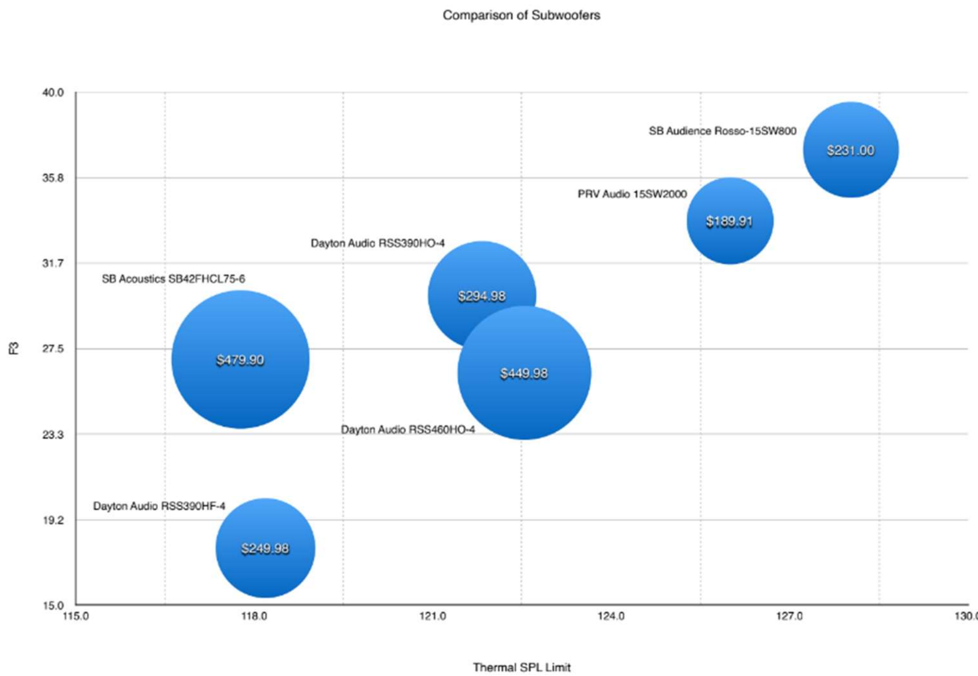

Figure 12 - comparison of F3, SPL, and price of subwoofer drivers

7.1 SB Acoustics 15" SB42FHCL75-6[31]

The SB Acoustics 15" SB42FHCL75-6 subwoofer looks great on paper. It has a high sensitivity and the ability to extend well into the 20 Hz region. The cone is also interesting, toting a honeycomb paper design. The cone is made from hard paper honeycomb that is layered with fiber glass skin layers. This cone would add a taste to the bass that could be awesome but is hard to tell until listened to. Based on the driver modeling, a bass boosted design in a vented box would produce a punchy response at 35 Hz. This is a good bass response, but I want something a little lower if I can get it.

7.2 Dayton Audio RSS390HF-4[32]

The Dayton Audio RSS390HF-4 subwoofer offers many appealing technical aspects. It has a sensitivity of 91.2 dB SPL. With the ability to handle 500 watts of power, this driver will be able to make use of the power output from my amplifier. It also has an F3 of 19.5 Hz which would support my desires for great low frequency extension. The cone is aluminum, so the driver will be more rigid in its movements. The price point is also at a comfortable level for me. Given I am doing left and right subwoofers, the cost of these drivers will add up. The technical specifications provided at this price point are making a pretty convincing argument.

[31] https://sbacoustics.com/product/15in-sb42fhcl75-6/

[32] https://www.daytonaudio.com/product/126/rss390hf-4-15-reference-hf-subwoofer-4-ohm

7.3 Dayton Audio RSS390HO-4[33]

The Dayton Audio RSS390HO-4 subwoofer is extremely similar to the RSS390HF-4. The main difference in the drivers are their higher sensitivity and power handling at 92.9 dB SPL and 800 watts respectively. It seems this driver is meant to play louder and take more power at a cost of the low frequency extension. This model only goes down to 20 Hz with an F3 of 21.5 Hz. This driver is also 50 dollars more expensive than the HF model. If I was only making one subwoofer, I would consider this driver to meet my desires. Given that I am making two subwoofers, the higher sensitivity is less necessary. The tradeoffs are minimal, but they are present enough to inform my decision.

8.0 Final Driver Selection

The following pages are my final driver selections based on the information in sections 6 and 7, as well as the modeling in Appendix A.

[33] https://www.daytonaudio.com/product/127/rss390ho-4-15-reference-ho-subwoofer-4-ohm

Dayton Audio

RS180-4[34]

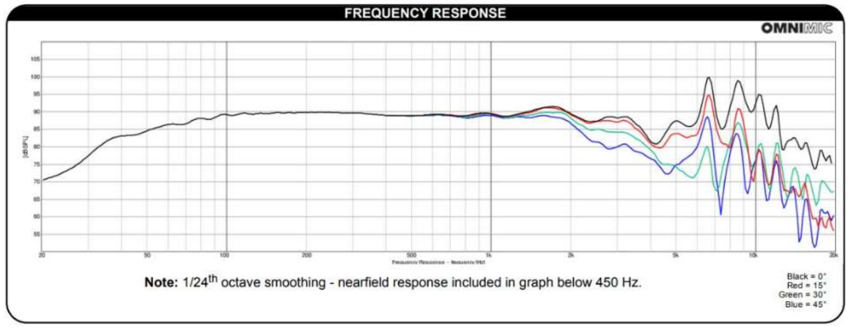

Figure 13 - manufacturer frequency response

Specifications:

Cost: $69.98
Size: 7”
+/- 1 in bandpass 100Hz to 2000 Hz
Breakup frequency: 2500 Hz
Breakup amplitude peak: +10 dB
Recommended crossover: 4th order at 1500 Hz
Thermal power handling: 60 watts at 89.2 dB SPL

Narrative:

I ended up going with the Dayton Audio RS180-4 given its flat frequency response, lower sensitivity, good thermal power handling, and great integration with my other two driver choices. The breakup frequency starting at 2500 Hz gives me enough wiggle room to cross over the woofer at 1500 Hz. My tweeter of choice much enjoys this crossover point, especially at lower levels. The driver will also go low enough to support the low frequency sound stage before my subwoofer takes over. With the proper tuning, as seen in Figure 14, this driver will extend to about 40 Hz while maintaining acceptable loudness.

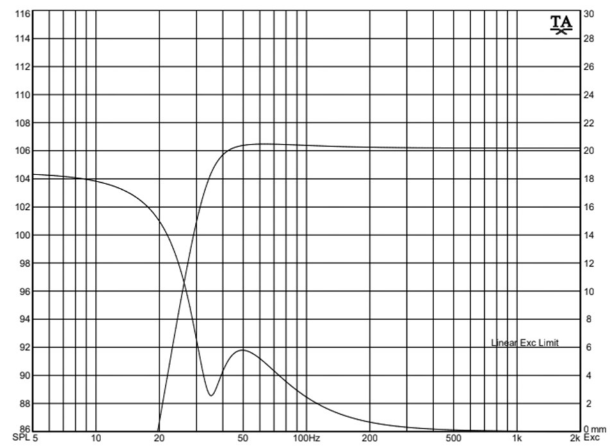

Figure 14 - squared roll off at 40 Hz

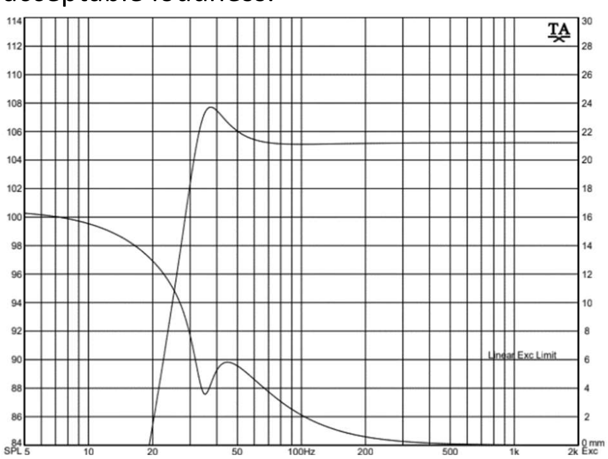

Figure 15 - bass boost at 35 Hz

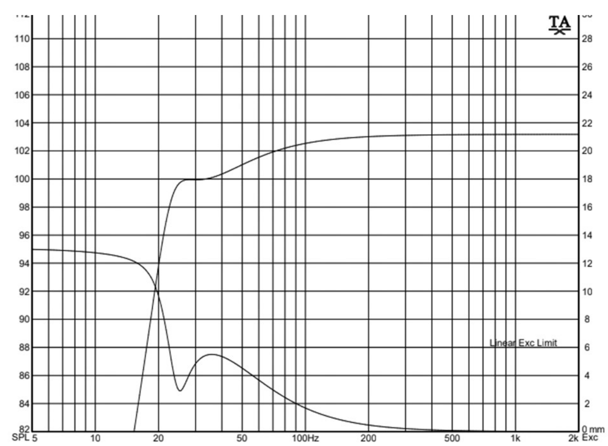

Figure 16 – extended shelf down to 25 Hz

[34] https://www.daytonaudio.com/images/resources/295-374--dayton-audio-rs180-4-spec-sheet.pdf

Dayton Audio
RSS390HF-4[35]

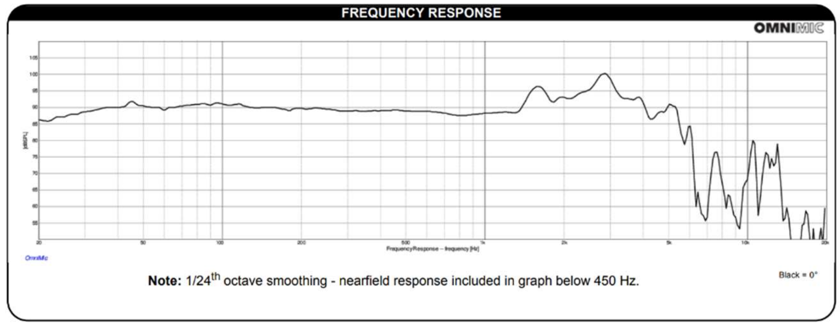

Figure 17 - manufacturer frequency response

Specifications:
Cost: $249.98
Size: 15”
+/- 1 in bandpass 20 Hz to 300 Hz
Breakup frequency: 1200 Hz
Breakup amplitude peak: +10 dB
Recommended crossover: 4th order at 125 Hz
Thermal power handling: 500 watts at 91.2 dB

Narrative:
I chose the Dayton Audio RSS390HF-4 for its exceptionally flat frequency response and low frequency extension capabilities. Based on Figure 18, this driver will be capable of achieving an F3 of 20 Hz. It also has an aluminum cone which will help the driver stay rigid when extending as low as I want to. It will also match my mid-frequency in terms of looks for a sleek design from bottom to top. For the price, this driver will provide me with everything I want out of my subwoofers.

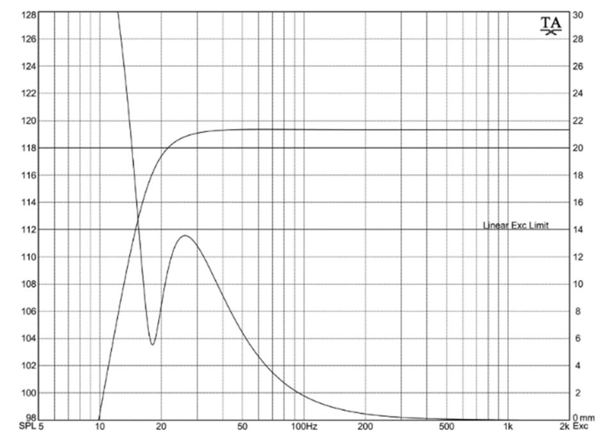

Figure 18 - squared roll off at 25 Hz

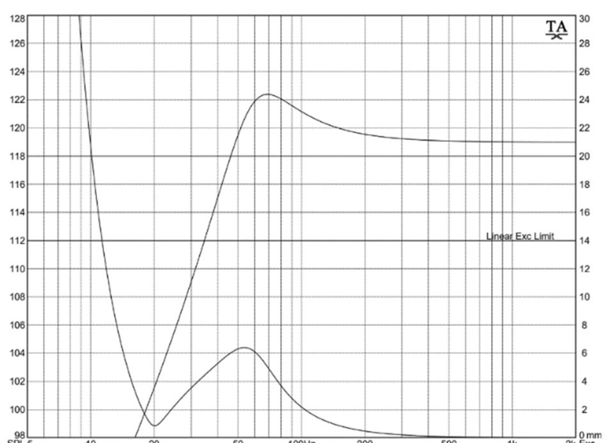

Figure 20 - bass boost at 70 Hz

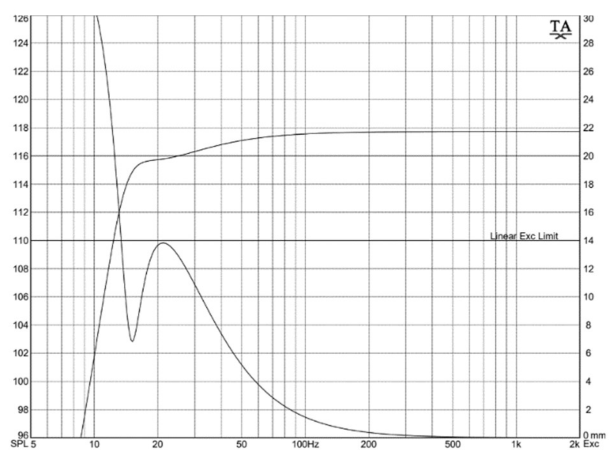

Figure 19 – extended shelf down to 15 Hz

[35] https://www.daytonaudio.com/images/resources/295-468-dayton-audio-rss390hf-4-specifications-46176.pdf

Scan Speak Discovery D2606/9200

I chose the Scan Speak Discovery D2606/9200 for three reasons. It has a great price, it has a very appealing natural second order roll off, and it will pair well with my woofer of choice. This tweeter has a higher sensitivity than my woofer, it will crossover low enough to help clean up some nasty breakup frequencies in my woofer, and it has an all-black design which will match my aesthetic theme. Overall, this tweeter seems to be the best choice for this system.

9.0 Construction

The construction process took me around 65 hours in total over the course of a week and a half. This section will highlight some important aspects of the build while showing some in progress construction pictures.

9.1 Planning

I started the process by planning, in great detail, how I was going to do everything. This included a day-by-day schedule of things I wanted to accomplish to keep me on track throughout the week. This plan would quickly alter on a day-to-day basis as certain tasks were easier than others, and some were much harder than anticipated. Nevertheless, I checked over this plan with Kent Cyr, our Technical Director at Michigan Tech, and Mat Moore, the Scene Shop coordinator at Michigan Tech. I also had them review my drafts to make sure I had a decent idea of how I was going to complete my cuts.

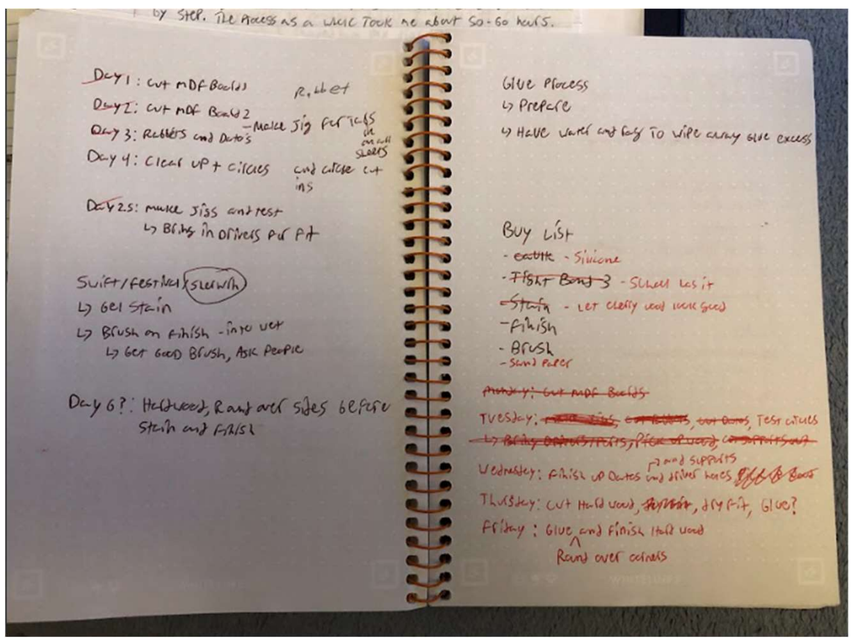

Figure 21 - day to day schedule from my notebook

9.2 Shop Build Days

I collected all of my materials and began working on constructing my cabinets. Mat Moore played a critical role in this process as a mentor and someone to bounce ideas off of during the build. He helped me through every step of the build process, the loudspeakers would not be what they are without Mat.

Figure 22 - panels for my speakers cut from MDF

The first day consisted of cutting out each of my panels from the two sheets of 4x8 MDF I purchased. I chose MDF due to its price point and ease of use. It also is resistant to warping which will help the speakers live a long life. I cut out all but the front faces of my cabinets. I decided to make the front baffles out of Cherry hardwood, which is where the name comes from. I completed my rabets on day one as well and started my datos going into day two.

Another part I worked on day two, apart from the datos, were the holes for my NL4 panel jacks. I decided to use Speakon connectors for my design given that I'm used to working with them. I liked the aesthetic look as well. I made a custom jig, as seen in Figure 23, to make sure each hole was cut exactly where I wanted it. Custom jigs would come up time and time again during the build process to keeps specific cuts consistent with each other. This strategy helped me produce a uniform product from cabinet to cabinet.

Figure 23 - custom jig used to ensure uniform cuts

One of the most labor-intensive parts of the process was drilling the holes for my drivers and ports. I had six drivers and four ports for a total of ten holes that needed to be cut. I wanted each driver and port to be flush with the face in which it lived. The plunge router, as seen on the left in Figure 24, was my tool of choice for this job. It is a tool capable of cutting round holes by rotating around a center pin. It can spin up to a diameter of 18 inches, so my 15 inch driver holes were no problem. It also has convenient stoppers on the plunge mechanism that can be adjusted to any height I wanted. I used a ruler and caliper to determine the thickness and diameter of each component. The actual drilling consumed about 45 minutes per hole, depending on the size. I also cut test holes for each component before cutting into my material to ensure that I would like the outcome of the cut. This strategy was critical for my cuts. Almost all of them were off the first time around by 1/16th of an inch, sometimes 1/8th of an inch. I could adjust my measurements and cut very clean holes that allowed my drivers to sit flush.

Figure 24 - set up for cutting port holes

Overall the cutting process went extremely well with very few errors on the faces of importance. I also rounded over all of the edges except for the rear edges. These round overs served to help deal with nasty diffraction over the sharp edges.

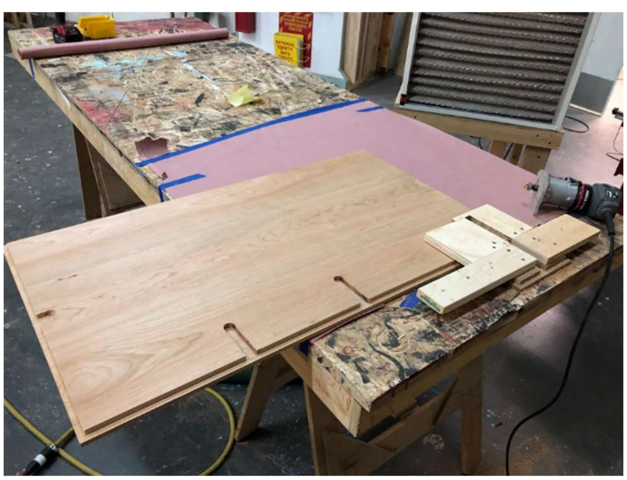

Figure 26 - jig used to cut uniform datos in subwoofer front baffle for interior supports

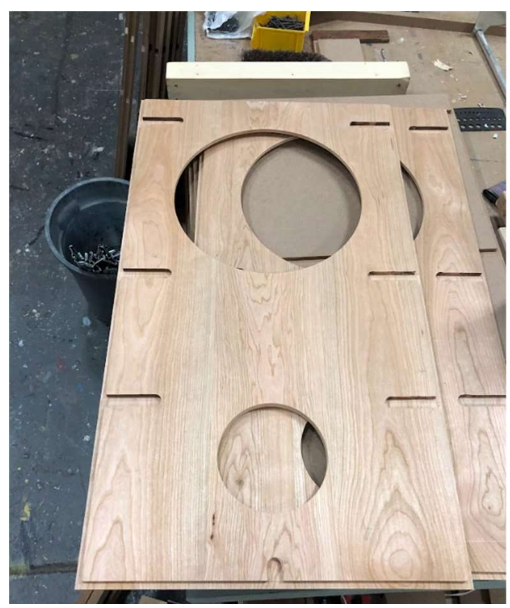

Figure 25 – rear side of front subwoofer baffle

After the cuts were done I dry fit and glued my speakers together. I used Titebond III to glue my cabinets together. It allowed for some time between applying the glue to the first piece and clamping down the completed box so I could make small adjustments as I put the cabinet together. Getting glue on every touching surface helped form air tight seals within the box. As some insurance, I added silicone around the inside edges to make sure no air was getting in or out (except through the port).

Figure 28 - dry fitting of mid/high cabinet

Figure 27 - clamping down mid/high cabinet while glue dries

Once the cabinets were glued and dried, I needed to get them into the paint room so they could receive their finish. I used satin oil based polyurethane to ensure that the wood wouldn’t warp and to allow the Cherry wood to thrive with its beautiful colors. I applied stain to both the interior and exterior sides of the front baffles to help deter future warping.

Figure 29 - cabinets drying after first coat of finish

The final step in the process was acoustically treating the interiors of the cabinets. I used wool to dampen the inside of the mid/high cabinets and rockwool to dampen the inside of the subwoofer cabinets. The wool was held in place with staples directly into the sides of the cabinet. The rockwool didn't hold that well with staples, so I used tie-line stretched the length of the cabinet to keep it in place. I screwed some screws into either side to tie onto. This strategy ended up working pretty well.

Figure 31 - wool inserted into mid/high cabinet

Figure 30 - rock wool inserted into subwoofer, held in place via tie-line

The speakers came out great. The drivers, ports, and NL4 jacks are perfectly flush to the cabinets. The Cherry wood looks absolutely stunning. The drivers match up and down the sets, I couldn't have imagined the speakers turning out any better. This was my first attempt at a woodworking project this large, so there are some noticeable blemishes up close. But for my purposes these speakers are as good as I could have constructed them. I plan to keep working on them in the future. Something I will do rather soon is paint the MDF. The tuning process took much longer than expected, refer to section 10, so I didn't get to it by the end of the semester. I will also be applying another coat of finish to help the Cherry pop even more.

Figure 32 - me sitting on my completed loudspeakers

10.0 Tuning

The following section is a summary of my tuning process. I tuned these speakers in the McArdle Blackbox Theatre. It's a large enough room to act as a pseudo-anechoic chamber. I conducted six different tuning sessions ranging anywhere from two hours to 6 hours. In total I spent twenty hours making sure the frequency responses of each driver and system were flat, the crossover points complemented the subwoofer to woofer and woofer to tweeter interactions, the ports were tuned to an acceptable frequency, the phase aligned between the tweeters, woofers, and subwoofers and, most importantly, that they sounded good to my ears. This process was much more taxing than I expected, but the end product is more than worth the effort put in. Smaart V8[36] and FuzzMeasure[37] were used to tune and collect data.

Figure 33 - final measurements taken in the listening position

10.1 Mid/High Performance

Figure 34 - mid/high being tested on a tall stand, wool used to eliminate reflections from the stand

Some of the earlier measurements were taken with the mid/high sitting on a tall stand to take accurate data with minimal reflections (Figure 34). This helped me get some initial data to determine important decisions, like where my crossover was going to sit. I decided to conduct my final measurements with the mid/highs on the subwoofer cabinets because that's what they were designed to do. This would give me an accurate reading as to how the cabinets would interact in a practical set up. The overall mid/high loudspeaker performance turned out satisfactory to my standards. They fall within a range of +/- 2.5 dB SPL at 89 dB from a distance of 20

[36] https://www.rationalacoustics.com/pages/smaart-main-page
[37] https://www.rodetest.com/

inches in the listening position. An Earthworks M50[38] was used to ensure that these readings were as true to the response as possible.

Looking at Figure 36, it can be determined that there is a +2.5 dB bump at 11,000 Hz. There is a -2 dB dip at 9000 Hz. Looking at some preliminary measurements in Appendix B, these bumps can most likely be eq'd out. Ignoring these two outliers would provide an overall response of +/- 1.5 dB.

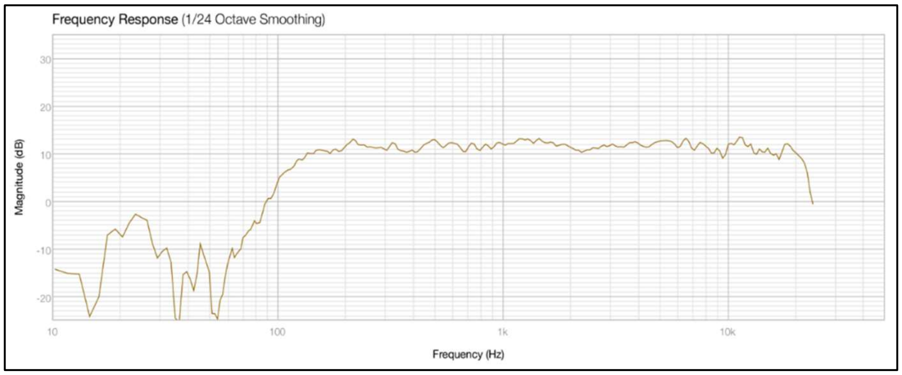

Figure 36 - right mid/high frequency response, 60 dB amplitude range

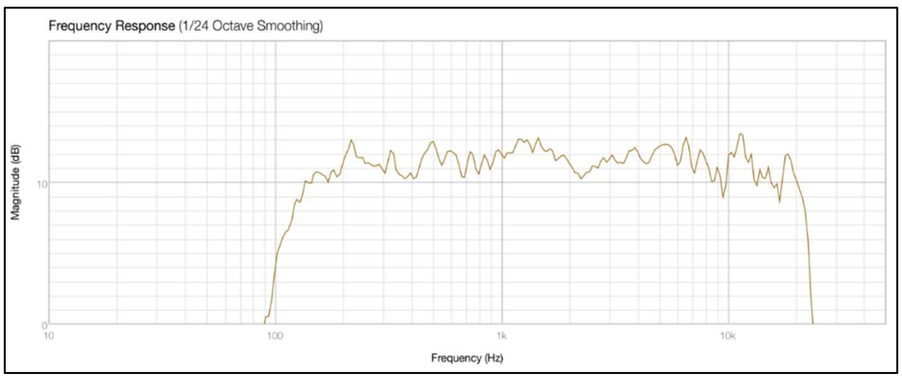

Figure 35 – right mid/high frequency response, 20 dB amplitude

The mid/highs have an F3 of 45 Hz. They have a low frequency crossover at 125 Hz allowing the subwoofers to take over at a comfortable frequency.

The tweeter and woofer of the mid/highs were given a crossover at 1500 Hz. The breakup frequency of the woofers was real nasty around 2850 Hz. Crossing over so low allowed me to avoid this frequency and produce a clean sound. My tweeter selection was critical in this decision given that my tweeter is capable of going that low. There are some bumps in both the tweeter and woofer where they intersect producing a slight bump in the frequency response (Figure 37). Going back and eq'ing this error out would help flatten the system.

[38] https://earthworksaudio.com/measurement-microphones/m50/

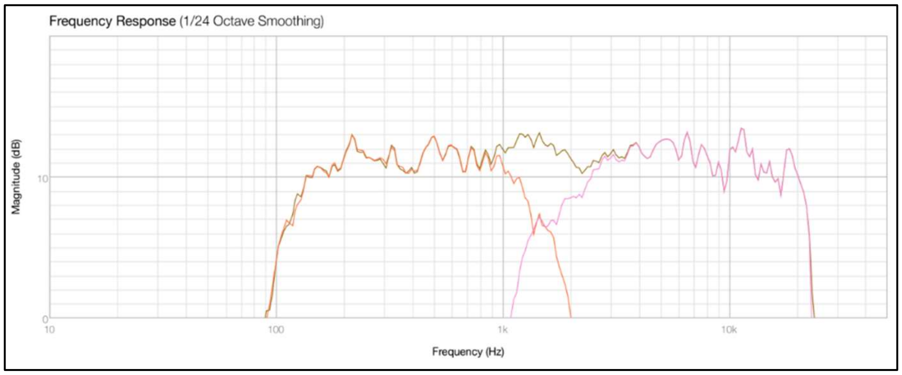

Figure 37 – integrated frequency response of the right mid/high

Figure 38 shows the horizontal off axis response at 0°, 15°, 30°, 45°, and 60°. The response is relatively uniform until 6000 Hz where some high frequency roll off can be seen. No oddities stand out upon viewing this data.

Figure 39 shows the vertical off axis response. This was done with the speaker on its side extending above the listening axis. Much like the horizontal, the response is relatively uniform until 6000 Hz. An expected oddity to point out is the large notch at 1500 Hz, my crossover frequency. This notch is a result of the phase between the tweeter and woofer worsening as you go farther off axis. The effects are not very detrimental until reaching 30-45° off axis.

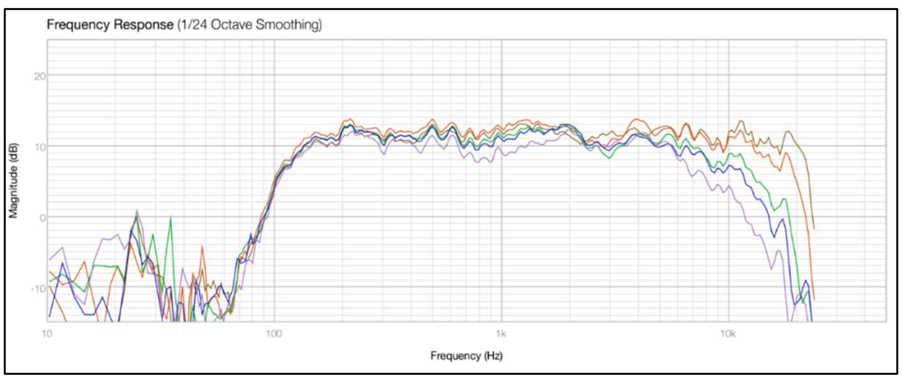

Figure 38 - right mid/high horizontal off axis response
Brown – On Axis / Red – 15° / Green - 30° / Blue - 45° / Purple - 60°

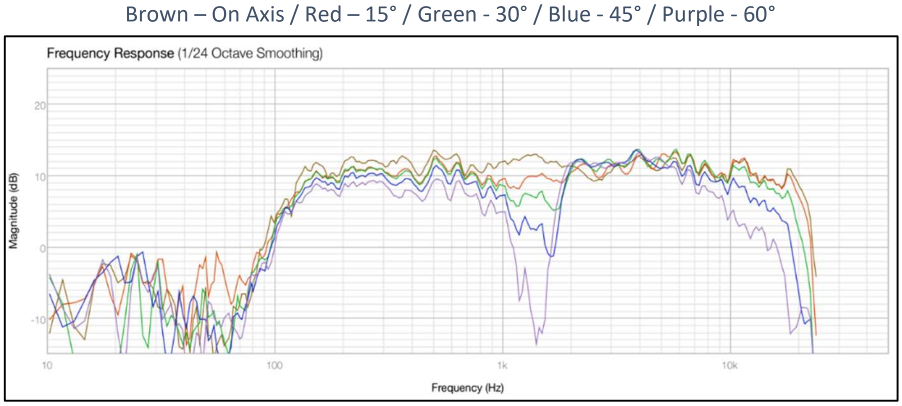

Figure 39 - right mid/high vertical off axis response
Brown – On Axis / Red – 15° / Green - 30° / Blue - 45° / Purple - 60°

Figure 40 shows the harmonic distortion of the 2nd and 3rd harmonics of the mid/highs. The distortion levels remain below one percent until the crossover frequency.

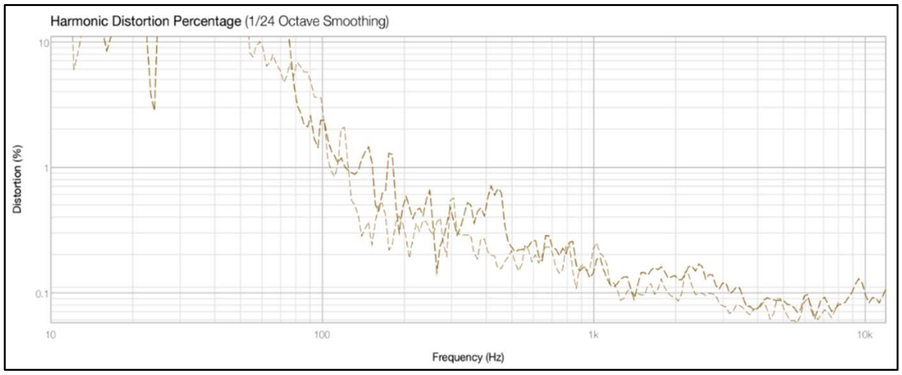

Figure 40 – 2nd and 3rd harmonic distortions of right mid/high

Figure 41 shows the step response of the right mid/high. The impulse starts 1 ms from the left of the graph, running for 10 ms to the end of the graph. The tweeter can be seen firing first, followed shortly by the woofer. The system resonates through the end of the graph but quickly comes to a halt within 15 ms.

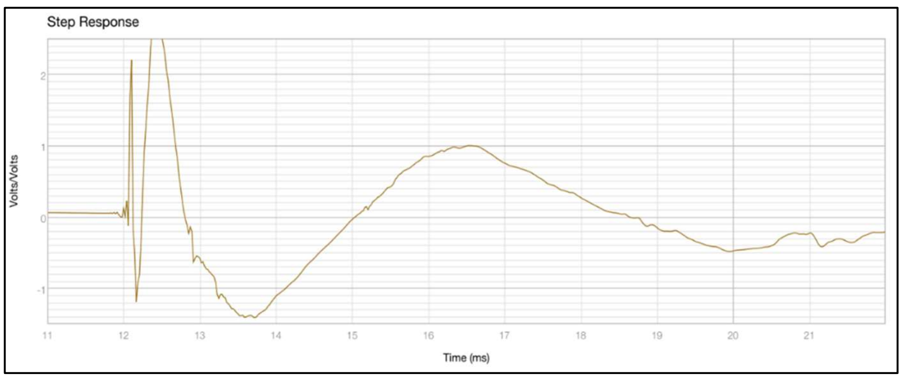

Figure 41 - step response of right mid/high

Overall, the mid/high components of the system turned out great with appealing data to show. There are some glaring issues that can be extracted from this data, but these issues are also easily fixed with some extra processing and time.

10.2 Subwoofer Performance

The subwoofers were raised 18 inches from the floor for the tuning process. Some acoustic absorption was placed on the ground between the subwoofer and microphone to help alleviate some of the floor bounce from interfering with the data. Before tuning my ports the subwoofers rolled off at 31 Hz.

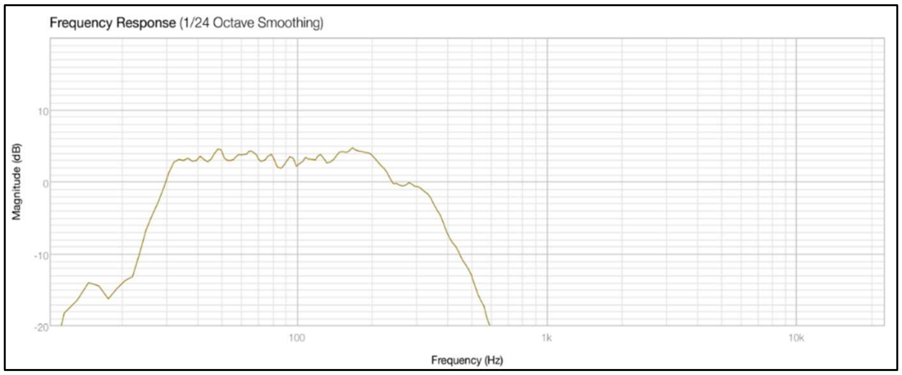

Figure 44 - subwoofer tuning before port implementation

My ports helped tremendously to extend the low frequency response of my subwoofers. As seen in Figures 43 and 44, the port was tuned to 24 Hz and brought the overall F3 down to 20 Hz.

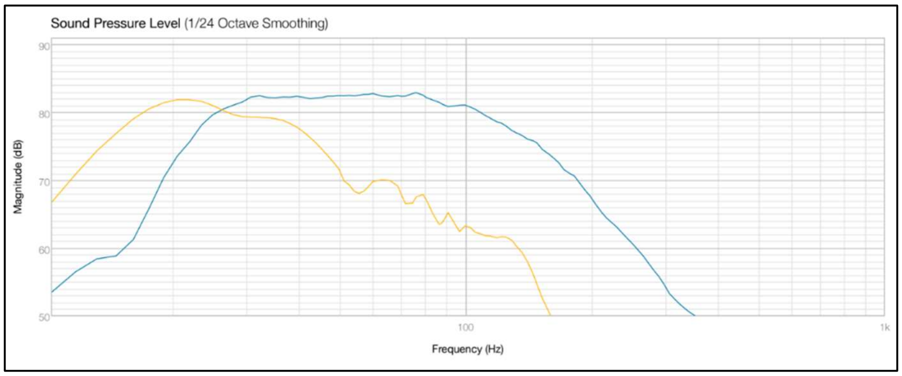

Figure 43 - subwoofer response (blue) and port response (yellow)

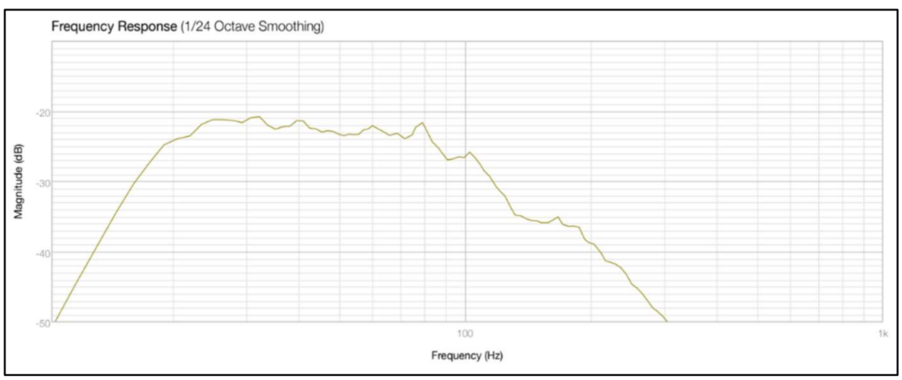

Figure 42 - overall subwoofer response after port tuning

Figure 45 shows the 2nd and 3rd harmonic distortions. The distortion dips below one percent for a moment in the operating range of the subwoofer before spiking back up. Looking at the 125 Hz region, I might consider lowering my crossover to avoid some spiking distortion levels.

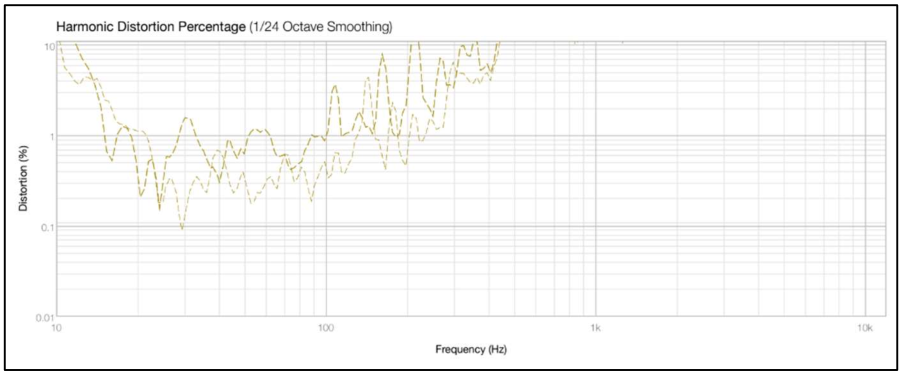

Figure 45 – 2nd and 3rd harmonic distortions of subwoofer

Overall, I am extremely satisfied with the outcome of my subwoofers. They sound great and extend lower than I expected. An F3 of 20 Hz is truly my best outcome for these subwoofers.

10.3 Individual Driver Performance

This section will cover the individual driver performance of the woofers and tweeters. The drivers were pretty similar with only minor differences from driver to driver, so each driver will not be covered. All of the data can be viewed in Appendix B.

The woofers were very flat in their operating range. They extend down 100 Hz with an F3 of 60 Hz. Adding the port to this equation extended this F3 down to 45 Hz. The breakup frequency discussed in section 10.1 can be seen in Figure 46.

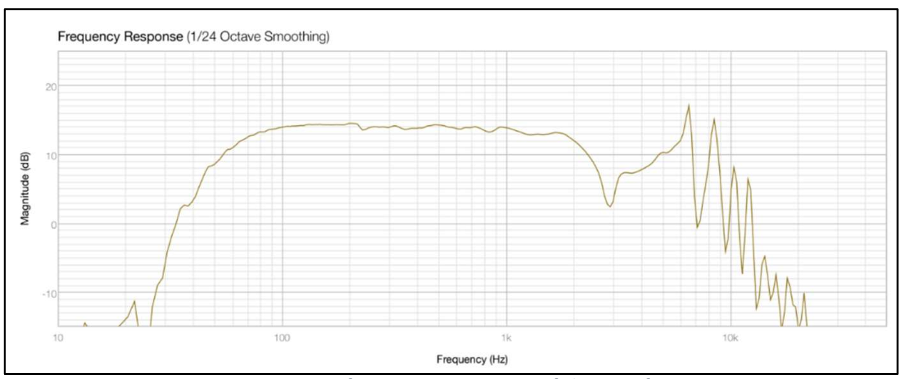

Figure 47 - frequency response of the woofer

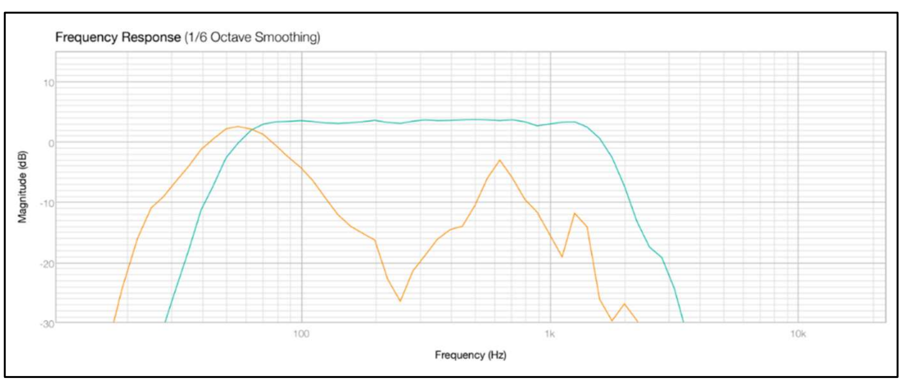

Figure 46 – frequency response of the woofer (blue) and port (orange)

Various crossovers were tested on the woofer with this breakup frequency in mind. Figure 48 shows these tests. Crossovers at 3000, 2000, and 1500 Hz were tested. A notch and peak can be seen in all responses, lowering in loudness as the crossover lowers in frequency. This data helped make the decision to place my crossover where it ended up.

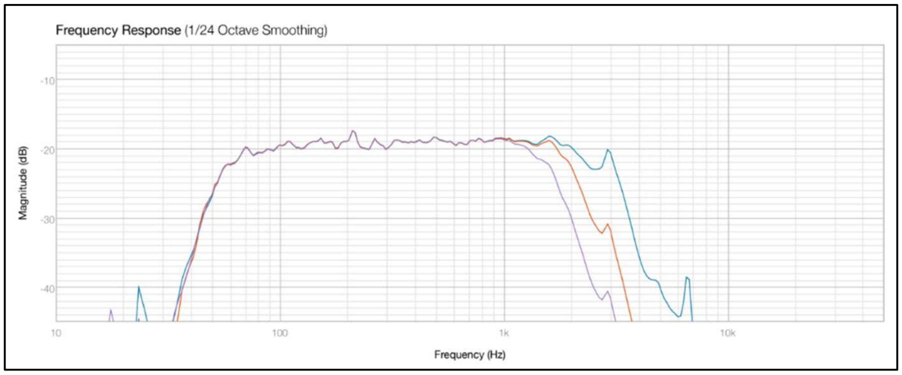

Figure 48 - crossovers at 3000 Hz (blue), 2000 Hz (red), and 1500 Hz (purple) tested on woofer

The tweeter is very flat down to 1100 Hz where I applied a crossover for testing to keep the tweeter safe. This flatness allowed me the flexibility to cross my woofer over where it needed to be. I didn't have to fight with breakup frequencies in both the tweeter and the woofer, just the woofer.

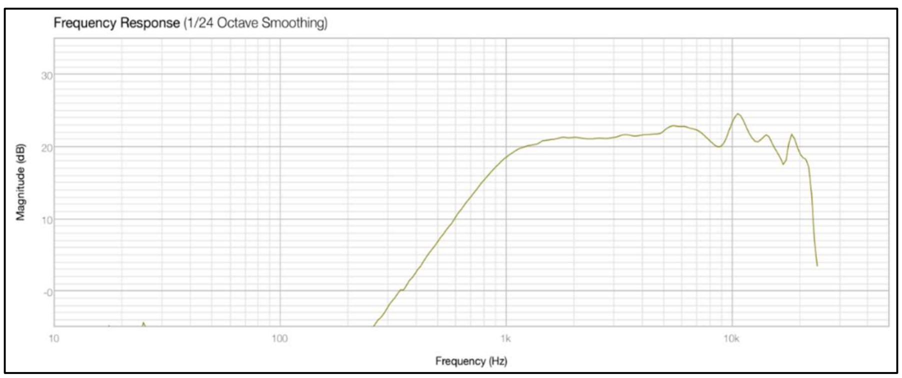

Figure 49 - frequency response of tweeter, crossed over at 1100 Hz to protect tweeter from lower frequencies

The vertical off axis response for the individual drivers surprised me. The woofers vertical off axis response is tight with not much variation across the spectrum, 0° to 60°. The tweeters were not as clean with some high frequency roll off past 6000 Hz.

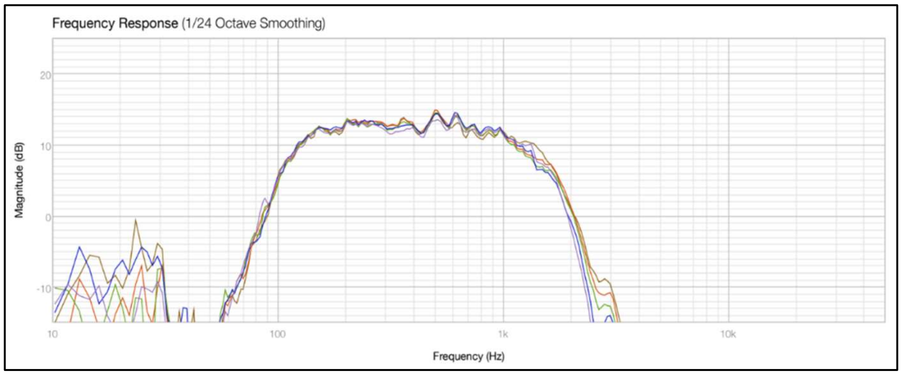

Figure 51 - vertical off axis response of woofer
Brown – On Axis / Red – 15° / Green - 30° / Blue - 45° / Purple - 60°

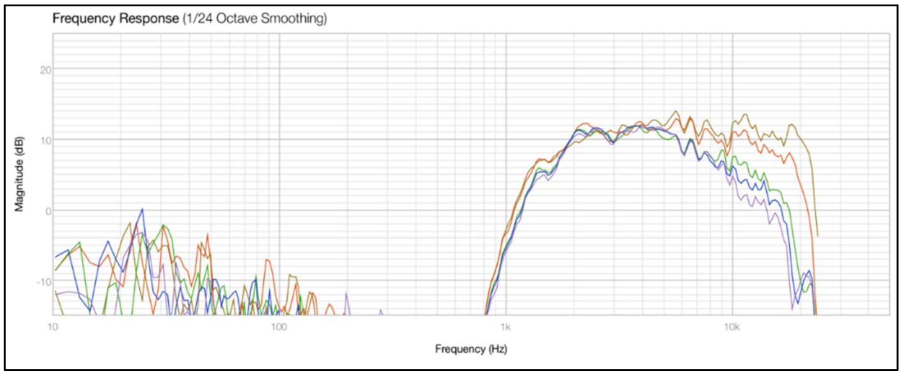

Figure 50 - vertical off axis response of tweeter
Brown – On Axis / Red – 15° / Green - 30° / Blue - 45° / Purple - 60°

10.4 Overall System Performance

Overall system measurements were more difficult to take than I anticipated. The floor bounce impacted the frequency response harshly, especially due to the larger distance between the microphone and speakers to capture the full image. The system was tuned relatively flat with coverage of all frequencies from 20 Hz to 20,000 Hz. There is some bulging in the subwoofer frequency range, but that adheres to my desires for some punchier bass. Simply turning the subwoofer down during testing would have delivered a more even frequency response.

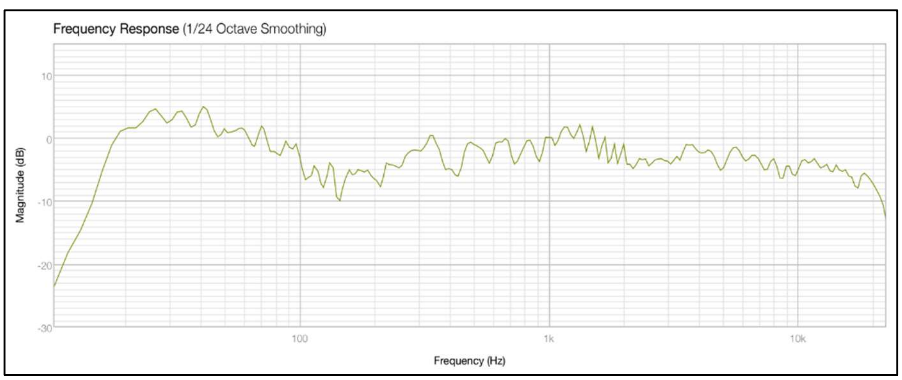

Figure 52 - full system frequency response

11.0 Concluding Thoughts and Thanks

It's the end of the semester, I have come full circle with this project. 15 weeks ago, I was only dreaming about what I could accomplish during the semester. I was researching, learning, theorizing, asking questions, and making progress towards the speakers I can now listen to. The process never slowed down either, it was all go right from the first class of the semester. I am extremely satisfied with the final product on all accounts. The sound stage is deep and rich, allowing every element of a song to pop. The subwoofers rumble with clarity and precision, achieving my goals of great low frequency extension. They are also aesthetically pleasing with the Cherry front baffles. This is not to say that they are perfect, as this was only my first attempt at tackling a project like this. I have listed some things that I would do differently for the second version of the Cherry Bombs.

First, they are just huge. The size of the speakers is a little impractical for mobility even though I tried to design them with mobility in mind. I am going to live with them though, hopefully I don't do too much moving around. I would do some more research on room gain and design a smaller subwoofer that would benefit from boundary effects to compensate for this.

Second, the midrange driver doesn't need to be seven inches. I love the driver. I think its sleek while supplying me with crisp sounds. After applying some modeling to the real world and figuring out how drivers interact with each other and the frequency spectrum, I could design a smaller mid/high speaker that is just as powerful. This would reduce cost, increase mobility and practicality while not sacrificing too much low end.

Third, I would give myself more time. Overall, many decisions were made in the interest of time. One semester is not a lot of time for a project like this, and I spent everyday working towards the outcome. More time during the tuning phase, construction phase, and research phase would increase the quality of the speakers. Not that the Cherry Bombs are low quality, but some serious improvements would need to be made if I wanted to consider marketing them.

Fourth, I would use higher quality material. Given everything I've said so far, the second version would be much smaller. This would allow me to spend more on some higher quality material. MDF is great and it was a fantastic introduction to woodworking and cabinet construction. Using a higher quality material would increase marketability, appeal, and so much more.

While there are many things I would do differently, there isn't a thing I would change about this version of the Cherry Bombs (except some eq'ing to flatten them out more). The changes listed above are encouraging as well. They give me something to strive for, and a reason to continue my studies in Transducer Theory. As I stated at the beginning of this paper, these speakers are only an introduction into Transducer Theory. I plan on taking everything I've learned and doing it all over again.

I would like to take a moment to thank Christopher Plummer. Chris is the reason this project came to fruition. Without his incredible advice and endless patience, I wouldn’t have been able to produce a product as sound as this. I threw questions at Chris almost every time I saw him this semester, inside and outside of class. He helped me not only design the system, but he also taught me everything I needed to know to be successful. And this teaching didn’t start this semester, it has been an ongoing process that started when I set foot in Walker as an audio student. Transducer Theory helped me solidify concepts that I have been grappling with over the past couple years and apply them to a real life scenario… loudspeakers. Without Chris I wouldn’t have found this avenue or taken on a project that took me around 300 hours in a semester. And for that I am forever grateful.

I would also like to thank Mat Moore and Kent Cyr for helping me out with the cabinet construction. Without their brainpower my cabinets wouldn’t be so clean and sturdy. They helped me bring my construction dreams to life, as well as teaching me some useful woodworking techniques.

Overall, I think I am much more confident as an individual coming out of this experience. The fact that I dove so hard at a project and saw it through to the end, while also producing something that satisfies my expectations… it was just a great learning process.

Thank you for reading.

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Appendix A – Driver Specifications & Modeling

Midrange Woofers

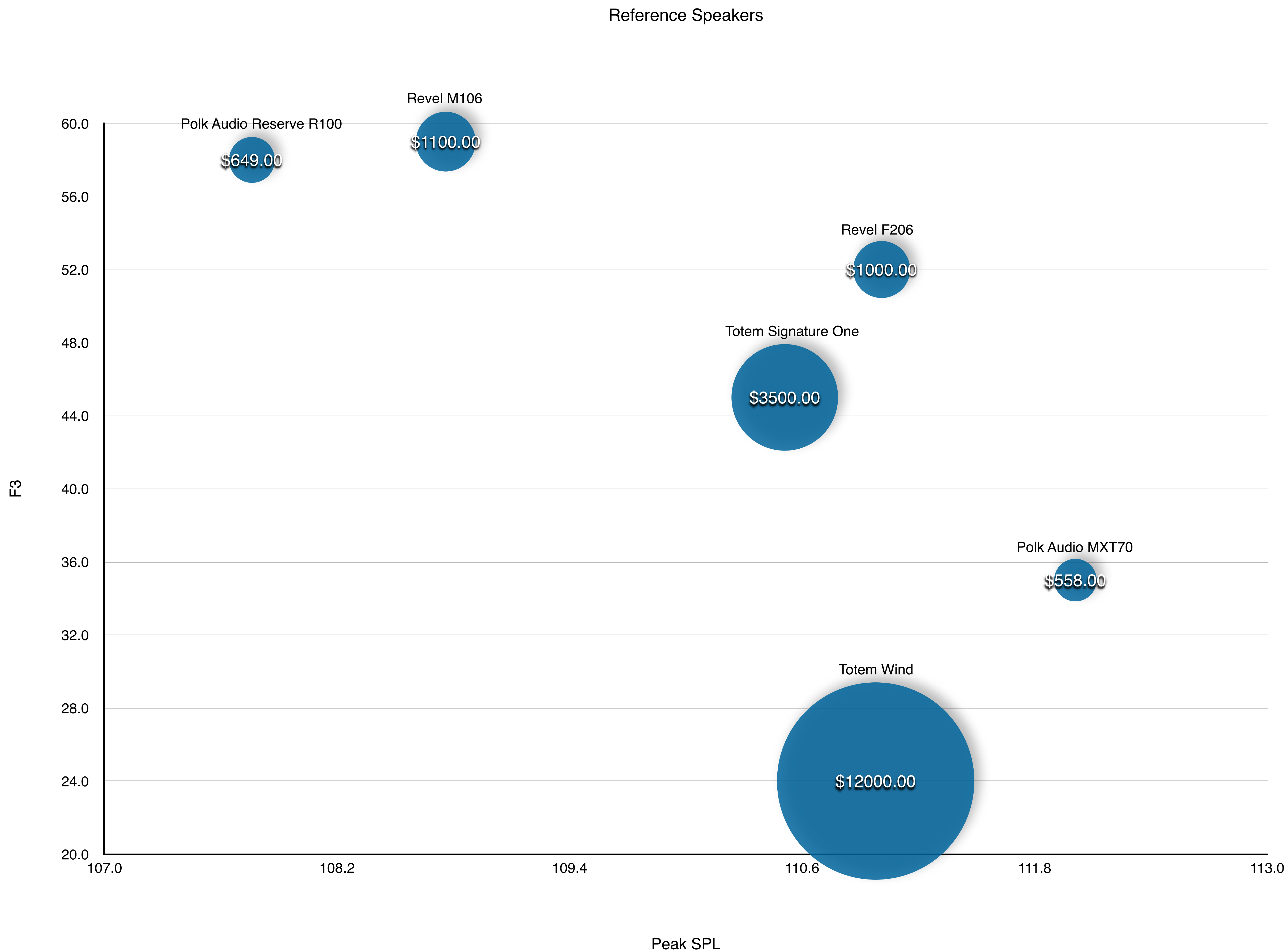
	Nominal Size	Cone	Price	Sensitivity	Power	Thermal SPL Limit	X-max	Sd cm2	Vas (liters)	Qts	Fs	Vb (liters)	Vb (cu feet)	Vd	F3	X-max SPL
Dayton Audio RS180-4	7”	Aluminum	$70.00	89.2	60	107.0	38	124.7	21.2	0.46	38.4	32.69	1.15	0.0474	31.7	117.3
Dayton Audio RS150-4	6”	Aluminum	$60.00	91.8	40	107.8	25	85	16.4	0.33	45.1	8.45	0.30	0.0213	60.4	117.9
Dayton Audio RS180P-8	7”	Paper	$70.00	89.8	60	107.6	6	126.7	22	0.34	45.8	12.51	0.44	0.0076	58.7	117.5
Scan Speak 18M/8631T	7”	Sliced Paper	$243.80	89	120	109.8	14.5	154	14	0.71	65	90.43	3.19	0.0223	28.6	116.8
Audax PR170M0	6.5”	Paper	$113.70	100	100	120.0	1	139	5.52	0.51	117	11.97	0.42	0.0014	83.2	117.4
Satori MR16P-4	6”	Paper	$192.00	92.5	40	108.5	3.1	119	47.2	0.25	31	9.73	0.34	0.0037	62.1	117.3
Comparison Loudspeakers							X-Max	Sd	H	W	D	Vb(in3)	Vb(ft3)	Vd		
Polk Audio MXT70	6.5"	Paper	$558.00	89	200	112.0			40.4	9.25	12.5	4671.25	2.70	0.0000	35.0	
Totem Wind	8.5”		$12000.00	87	250	111.0			44.3	10.7	14	6636.14	3.84	0.0000	24.0	
Revel F206	6.5”	Aluminum	$1000.00	88	200	111.0			41.4	9.8	13.6	5517.79	3.19	0.0000	52.0	
Totem Signature One	6.5"	cellulose-acrylate	$3500.00	87.5	200	110.5			13.77	7.67	10.62	1121.64	0.65	0.0000	45.0	
Polk Audio Reserve R100	5.25”	Paper	$649.00	86	150	107.8			12.8	6.5	10.2	848.64	0.49	0.0000	58.0	
Revel M106	6.5”	Aluminum	$1100.00	87	150	108.8			15	8.3	11	1369.50	0.79	0.0000	59.0	

Subwoofers

	Nominal Size	Cone	Price	Sensitivity	Power	Thermal SPL Limit	X-max	Sd cm2	Vas (liters)	Qts	Fs	Vb (liters)	Vb (cu feet)	Vd	F3	X-max SPL
PRV Audio 15SW2000	15”	Aluminum	$189.91	96	1000	126.0	12.5	908	61.53	0.55	52.9	171.13	6.04	0.1135	33.7	118.6
SB Audience Rosso-15SW800	15”	Paper	$231.00	99	800	128.0	11.28	850.1	87.6	0.46	45	135.09	4.77	0.0959	37.2	118.7
SB Acoustics SB42FHCL75-6	15”	Hard Paper Honeycomb	$479.90	93	300	117.8	11.5	850	462	0.31	18.4	193.72	6.84	0.0978	27.0	118.1
Dayton Audio RSS390HO-4	15”	Aluminum	$294.98	92.8	800	121.8	12	829.6	168	0.32	21.5	78.22	2.76	0.0996	30.1	118.3
Dayton Audio RSS390HF-4	15”	Aluminum	$249.98	91.2	500	118.2	14	829.6	212	0.43	19.5	261.70	9.24	0.1161	17.8	117.5
Dayton Audio RSS460HO-4	18”	Aluminum	$449.98	93	900	122.5	12.75	1164	272	0.32	18.8	126.65	4.47	0.1484	26.3	118.4

Tweeters

	Nominal Size	Cone	Price	Resonant Freq (Hz)	Sensitivity	Long Term Power	Short Term Power	Thermal SPL Limit	Mechanical SPL Limit
Hi-Vi Q1R	1”	Fabric	$18.80	1000	89	15		100.8	
Seas Prestige 19TFF1	0.75”	Soft	$44.40	1700	88	90	220	107.5	111.4
ScanSpeak Discovery D2606/9200	1”	Soft	$44.60	1100	91.5	100	200	111.5	114.5
ScanSpeak Discovery D2604/8300	1”	Soft	$50.70	630	92	100	240	112.0	115.8
SB Acoustics SB26CDC-C000-4	1”	Ceramic	$61.40	690	89	100		109.0	
SB Acoustics SB29RDAC-C000-4	1”	Soft	$64.40	600	93	100		113.0	
Comparison Loudspeakers									
Polk Audio MXT70	1”	Terylene	$558.00		89	200		112.0	
Totem Wind	1”	Aluminum	$12000.00		87	250		111.0	
Revel F206	1”	Aluminum	$1000.00		88	200		111.0	
Totem Signature One	1”	Aluminum	$3500.00		87.5	200		110.5	
Polk Audio Reserve R100	1”	Paper	$649.00		86	150		107.8	
Revel M106	1”	Aluminum	$1100.00		87	150		108.8	



Reference Speakers
F3
60.0
56.0
52.0
48.0
44.0
40.0
36.0
32.0
28.0
24.0
20.0
107.0
108.2
109.4
110.6
111.8
113.0
Peak SPL
Polk Audio Reserve R100
$649.00
Revel M106
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Totem Signature One
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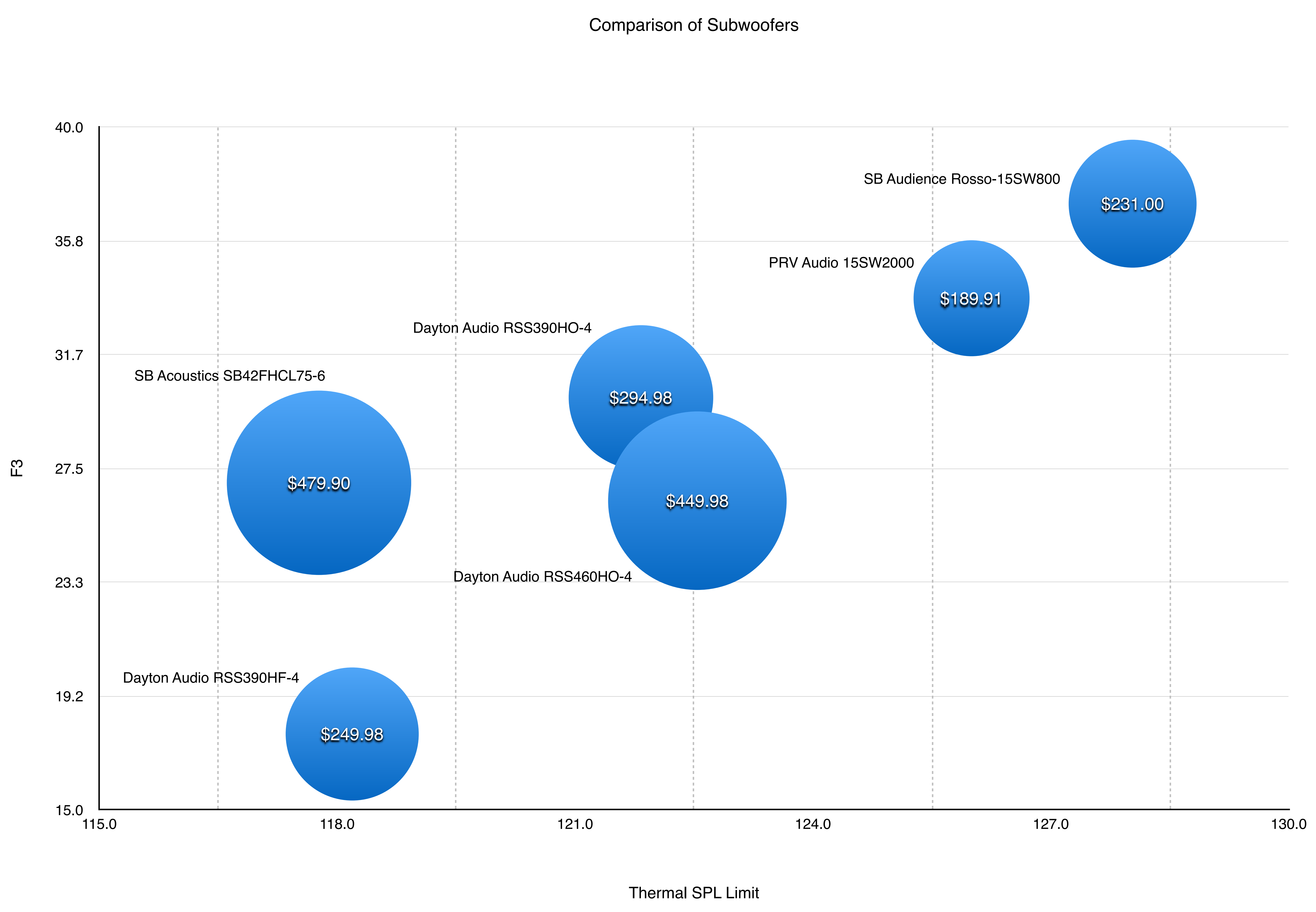
Comparison of Subwoofers
F3
40.0
35.8
31.7
27.5
23.3
19.2
15.0
115.0
118.0
121.0
124.0
127.0
130.0
Thermal SPL Limit
SB Audience Rosso-15SW800
$231.00
PRV Audio 15SW2000
$189.91
Dayton Audio RSS390HO-4
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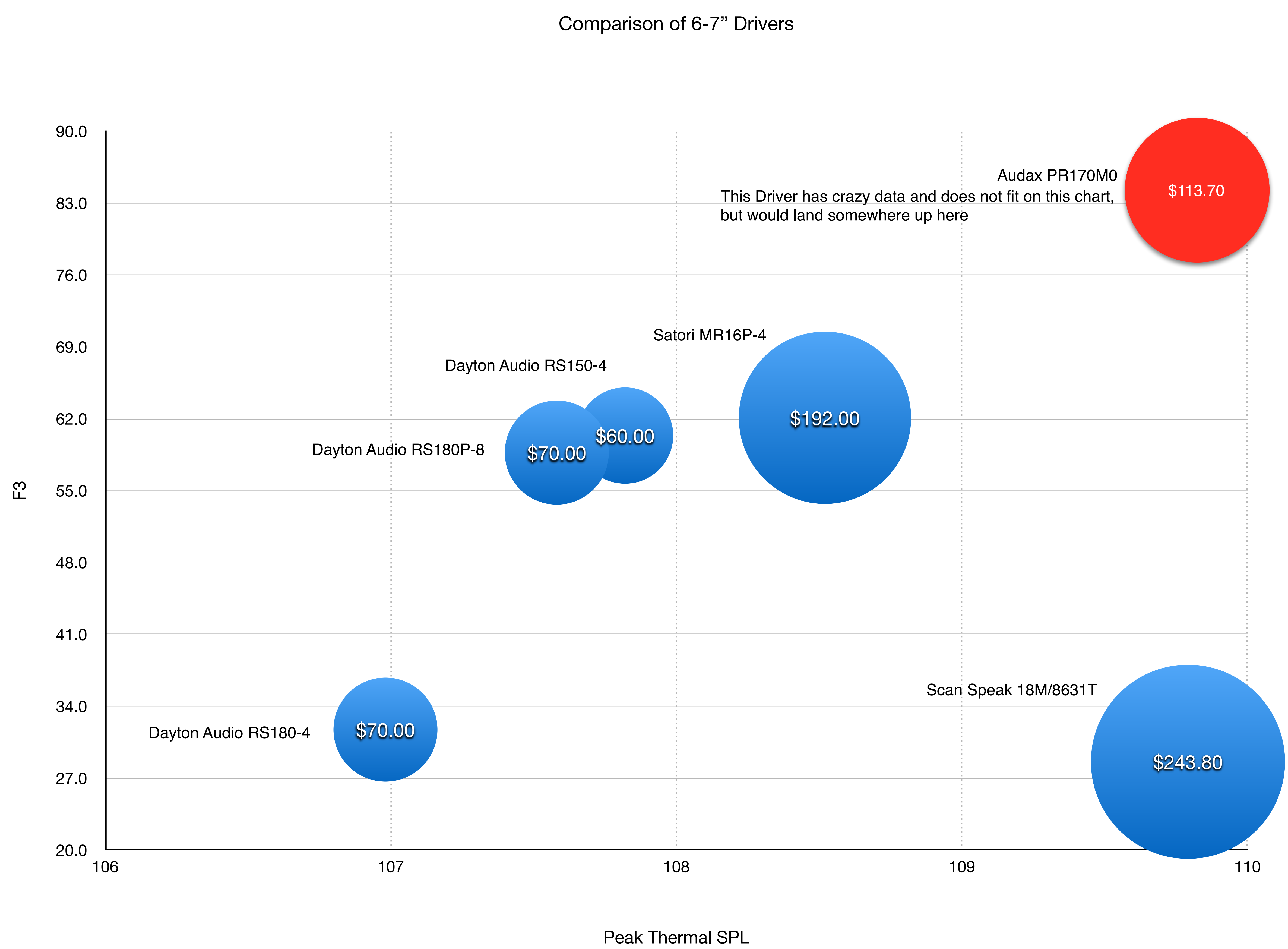
SB Acoustics SB42FHCL75-6
$479.90
$449.98
Dayton Audio RSS460HO-4
Dayton Audio RSS390HF-4
$249.98


Comparison of 6-7” Drivers
90.0
83.0
76.0
69.0
62.0
55.0
48.0
41.0
34.0
27.0
20.0
F3
106
107
108
109
110
Peak Thermal SPL
Audax PR170M0
This Driver has crazy data and does not fit on this chart,
but would land somewhere up here
$113.70
Satori MR16P-4
$192.00
Dayton Audio RS150-4
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Dayton Audio RS180P-8
$70.00
Dayton Audio RS180-4
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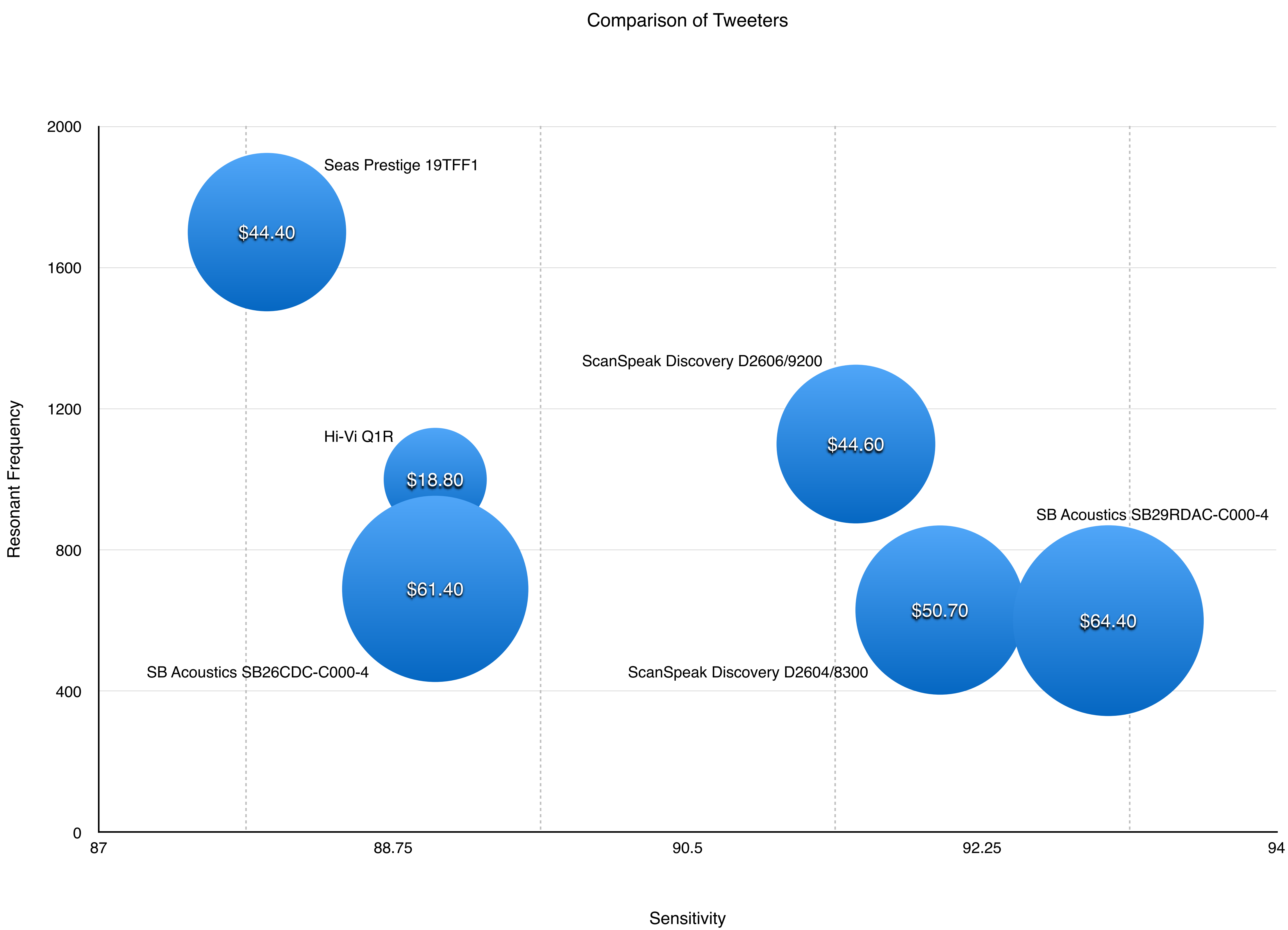
Scan Speak 18M/8631T
$243.80


Comparison of Tweeters
Resonant Frequency
2000
1600
1200
800
400
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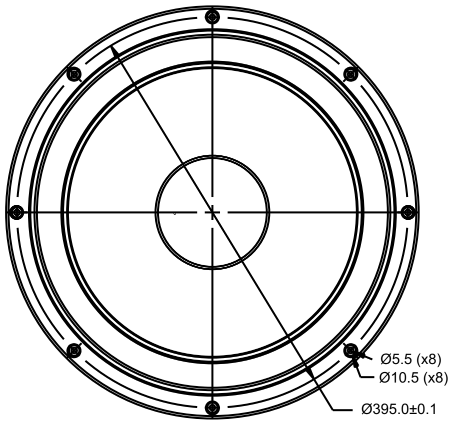
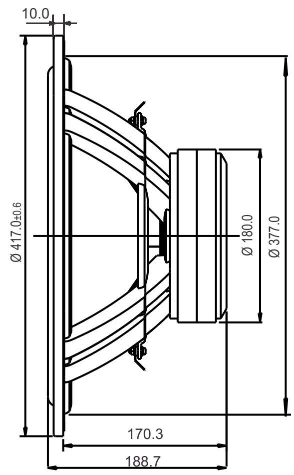
88.75
90.5
92.25
94
Sensitivity
Seas Prestige 19TFF1
$44.40
ScanSpeak Discovery D2606/9200
$44.60
Hi-Vi Q1R
$18.80
$61.40
SB Acoustics SB26CDC-C000-4
ScanSpeak Discovery D2604/8300
$50.70
SB Acoustics SB29RDAC-C000-4
$64.40

SB ACOUSTICS

15" SB42FHCL75-6





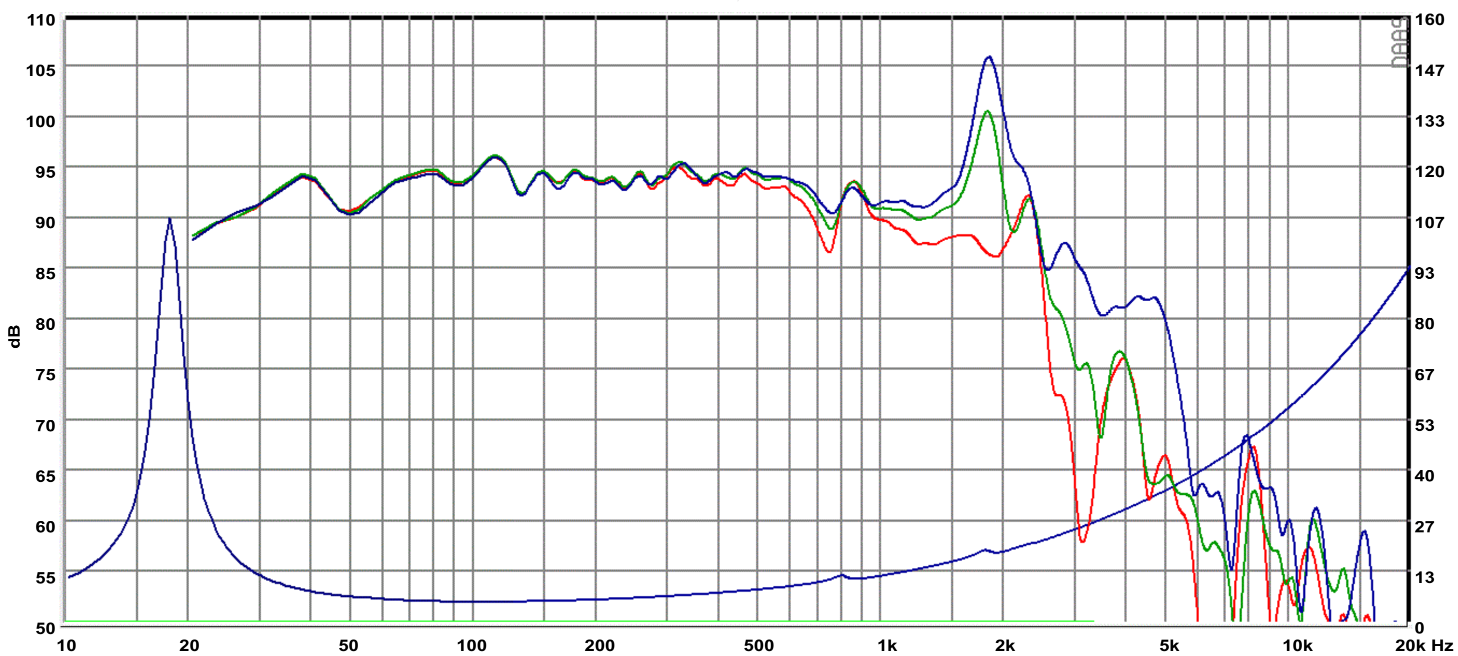
FEATURES

- Light weight rigid honeycomb cone (hard paper honeycomb with fiber glass skin layers).
- 3" copper voice coil for improved power handling.
- Long life silver lead wires.
- Vented pole piece for minimum compression.
- Vented cast aluminum chassis for optimum strength and low compression.
- Low damping rubber surround for improved dynamic linearity.
- Non-conducting fiber glass voice coil former for minimum damping.
- Large motor system

Specs :

Nominal Impedance	6 Ω	Free air resonance, Fs	18.4 Hz
DC resistance, Re	4.6 Ω	Sensitivity (2.83 V / 1 m)	93 dB
Voice coil inductance, Le	2.1 mH	Mechanical Q-factor, Qms	7.4
Effective piston area, Sd	850 cm^2	Electrical Q-factor, Qes	0.32
Voice coil diameter	75.6 mm	Total Q-factor, Qts	0.31
Voice coil height	31 mm	Moving mass incl.air, Mms	166 g
Air gap height	8 mm	Force factor, Bl	16.7 Tm
Linear coil travel (p-p)	23 mm	Equivalent volume, Vas	462 liters
Magnetic flux density	1.1 T	Compliance, Cms	0.45 mm/N
Magnet weight	3.6 kg	Mechanical loss, Rms	2.6 kg/s
Net weight	10.2 kg	Rated power handling*	300 W

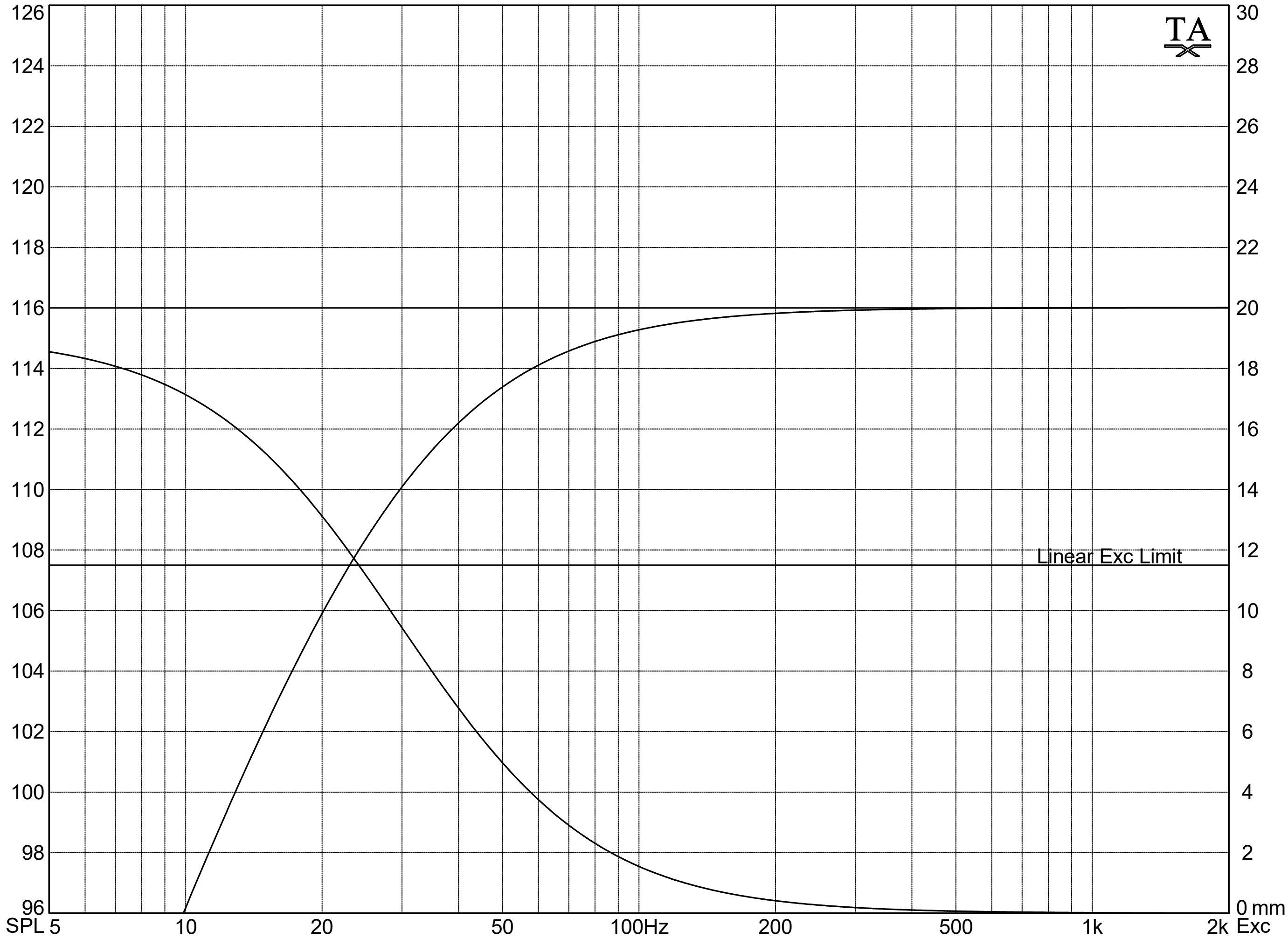
* IEC 268-5, T/S parameters measured on drive units that are broken in.



(IEC baffle, mic. distance 31.6 cm, SPL shown for 2.83 V / 1 m)

Response Curve :
------ (Blue) : on axis
------ (Green) : 30° off-axis
-------- (Red) : 60° off-axis

REV. 1 (11.03.2016)



Driver Parameters

Driver: SB Acoustics SB42FHCL75-6

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	93	dB SPL
Free Air Resonance	f(s) =	18.4	Hz
Total Q	Q(ts) =	0.31	
Electrical Q	Q(es) =	0.32	
Mechanical Q	Q(ms) =	7.4	
Equivalent Volume	V(as) =	16.32	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	4.6	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	11.5	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	10.19	cu ft
Closed Box Q	Q(tc) =	0.5	
System Resonance	F(sc) =	29.68	Hz
Compliance Ratio	alpha =	1.601	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	200	Watts
SPL Distance	D =	1	m

My Company
My Address, line 1
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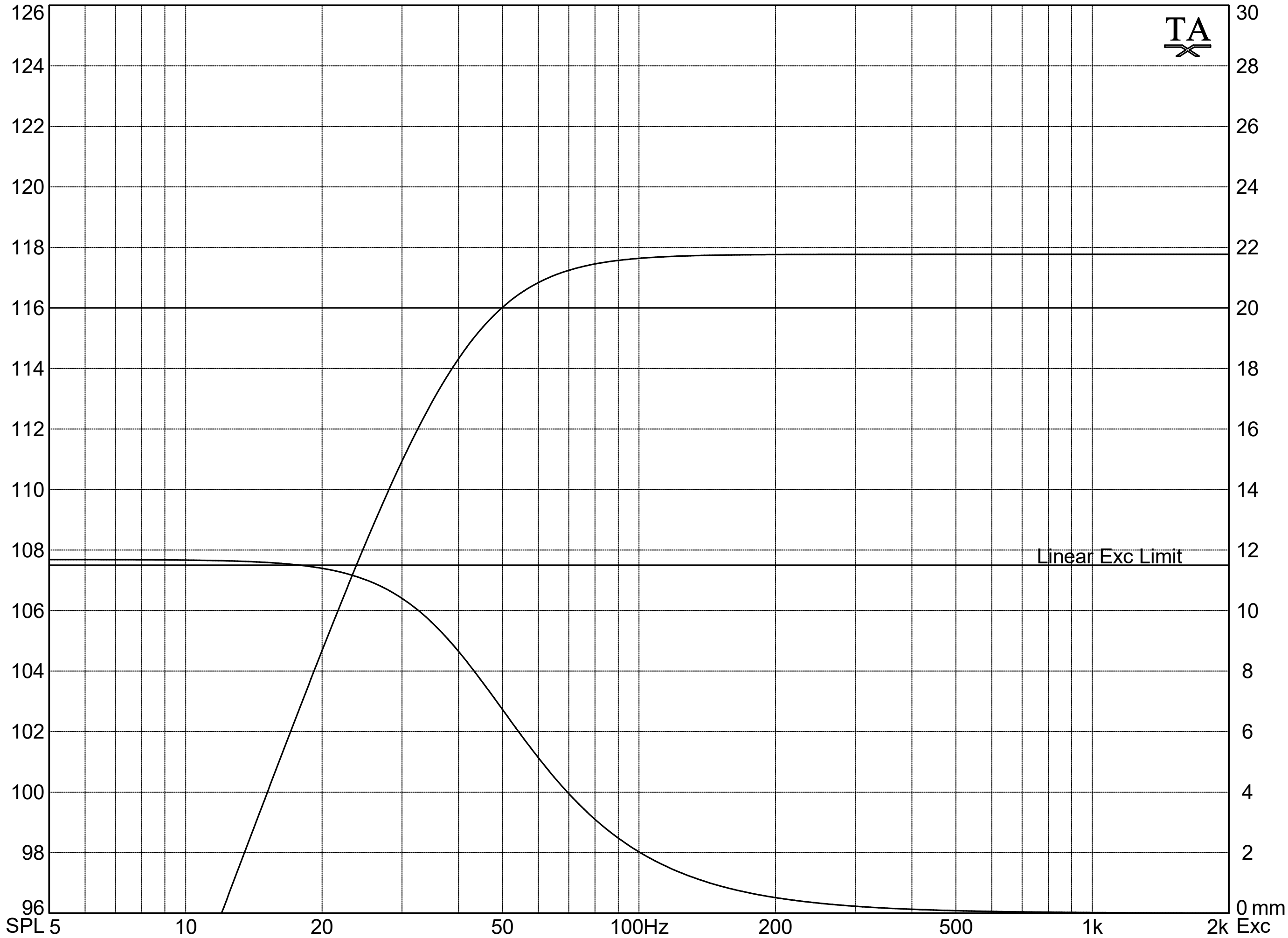
My Phone

System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: SB Acoustics SB42FHCL75-6

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	93	dB SPL
Free Air Resonance	f(s) =	18.4	Hz
Total Q	Q(ts) =	0.31	
Electrical Q	Q(es) =	0.32	
Mechanical Q	Q(ms) =	7.4	
Equivalent Volume	V(as) =	16.32	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	4.6	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	11.5	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	3.883	cu ft
Closed Box Q	Q(tc) =	0.707	
System Resonance	F(sc) =	41.96	Hz
Compliance Ratio	alpha =	4.2	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	300	Watts
SPL Distance	D =	1	m

My Company
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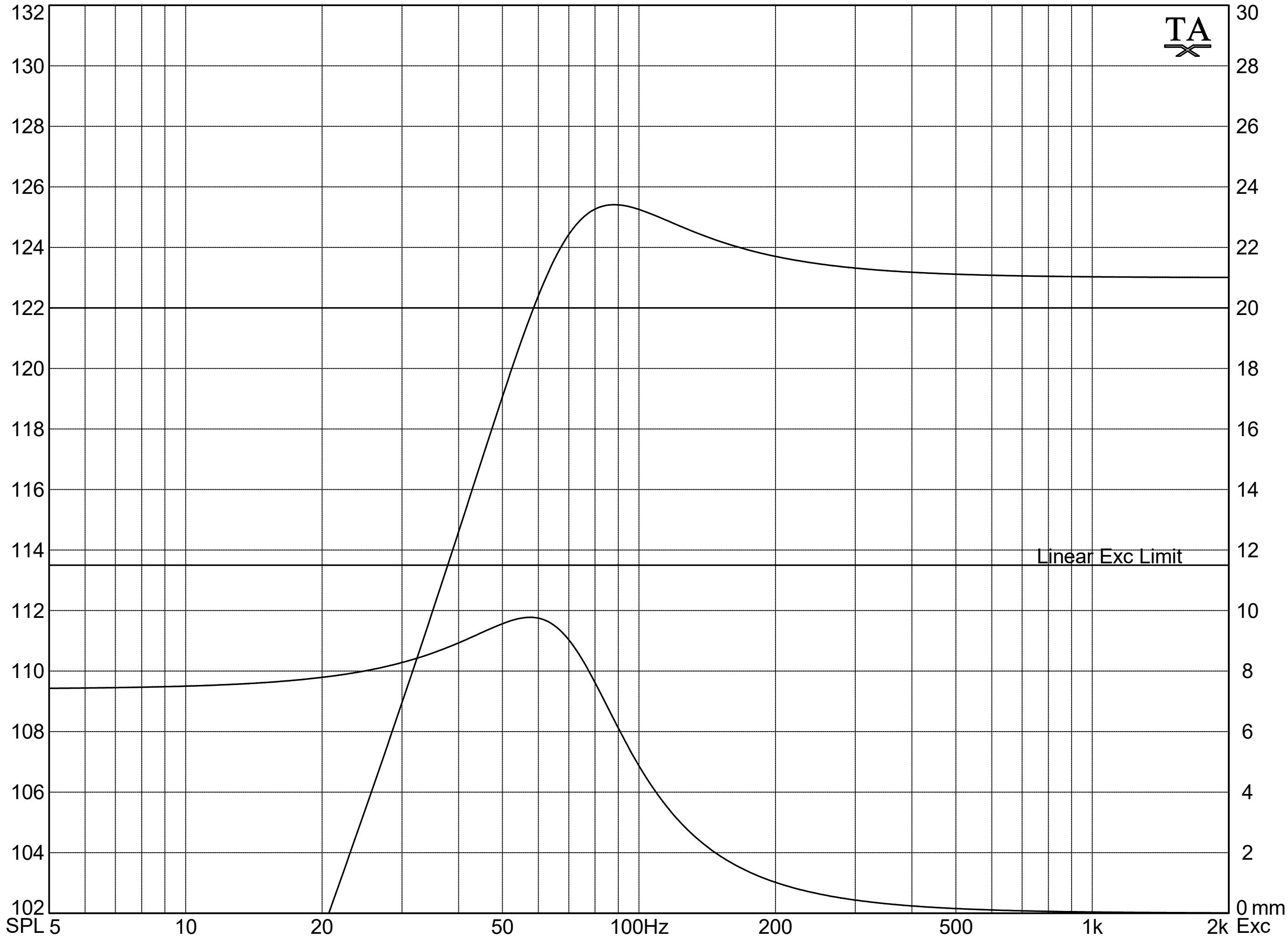
My Phone

System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: SB Acoustics SB42FHCL75-6

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	93	dB SPL
Free Air Resonance	f(s) =	18.4	Hz
Total Q	Q(ts) =	0.31	
Electrical Q	Q(es) =	0.32	
Mechanical Q	Q(ms) =	7.4	
Equivalent Volume	V(as) =	16.32	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	4.6	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	11.5	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	1.167	cu ft
Closed Box Q	Q(tc) =	1.2	
System Resonance	F(sc) =	71.22	Hz
Compliance Ratio	alpha =	13.98	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	1000	Watts
SPL Distance	D =	1	m

My Company
My Address, line 1
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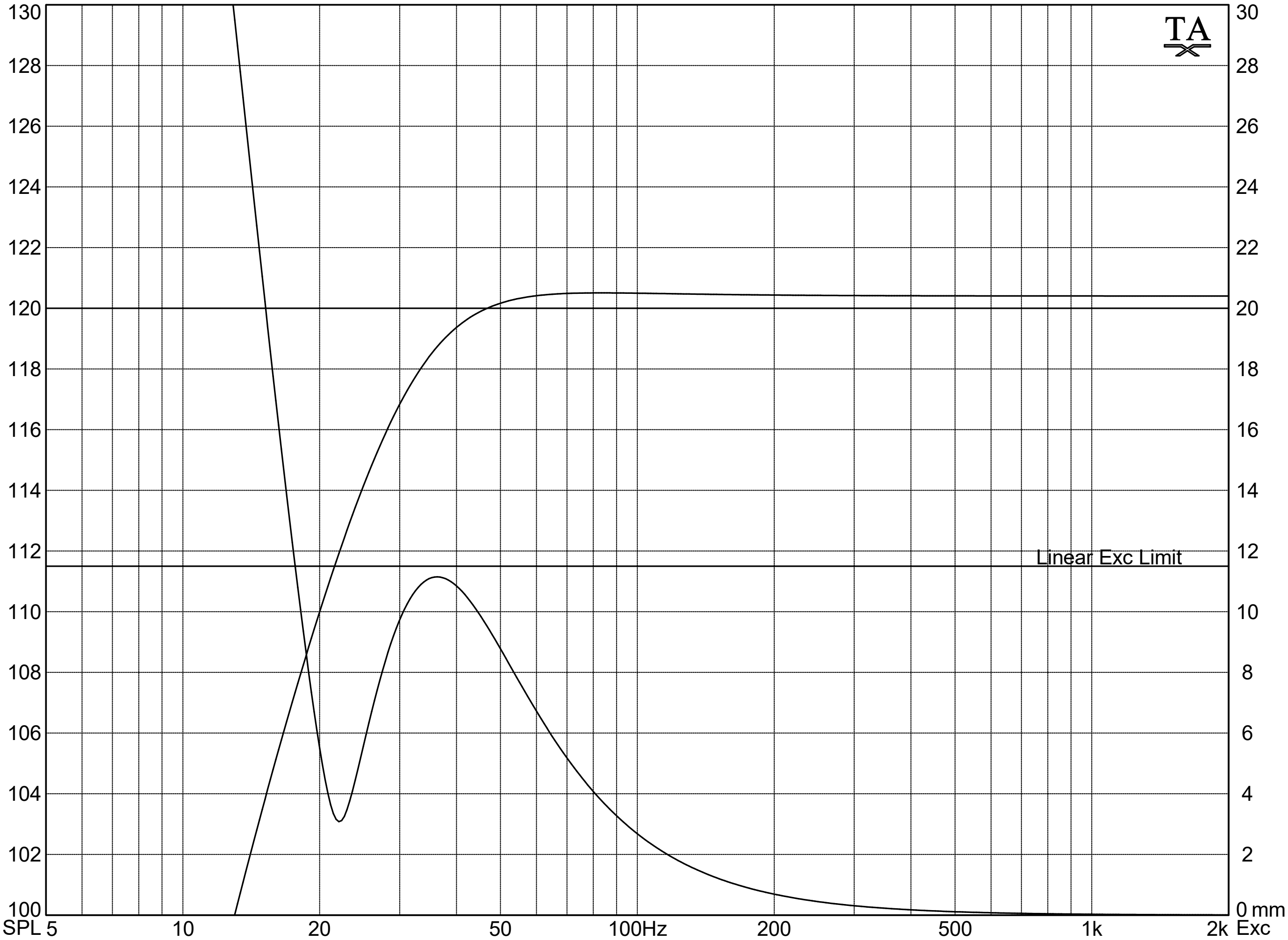
My Phone

System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: SB Acoustics SB42FHCL75-6

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	93	dB SPL
Free Air Resonance	f(s) =	18.4	Hz
Total Q	Q(ts) =	0.31	
Electrical Q	Q(es) =	0.32	
Mechanical Q	Q(ms) =	7.4	
Equivalent Volume	V(as) =	16.32	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	4.6	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	11.5	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	5	cu ft
Closed Box Q	Q(tc) =	0.6401	
Box Frequency	F(B) =	22	Hz
Min Rec Vent Area	S(vMin) =	26.7	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	3.263	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	550	Watts
SPL Distance	D =	1	m

My Company
My Address, line 1
My Address, line 2
My Country
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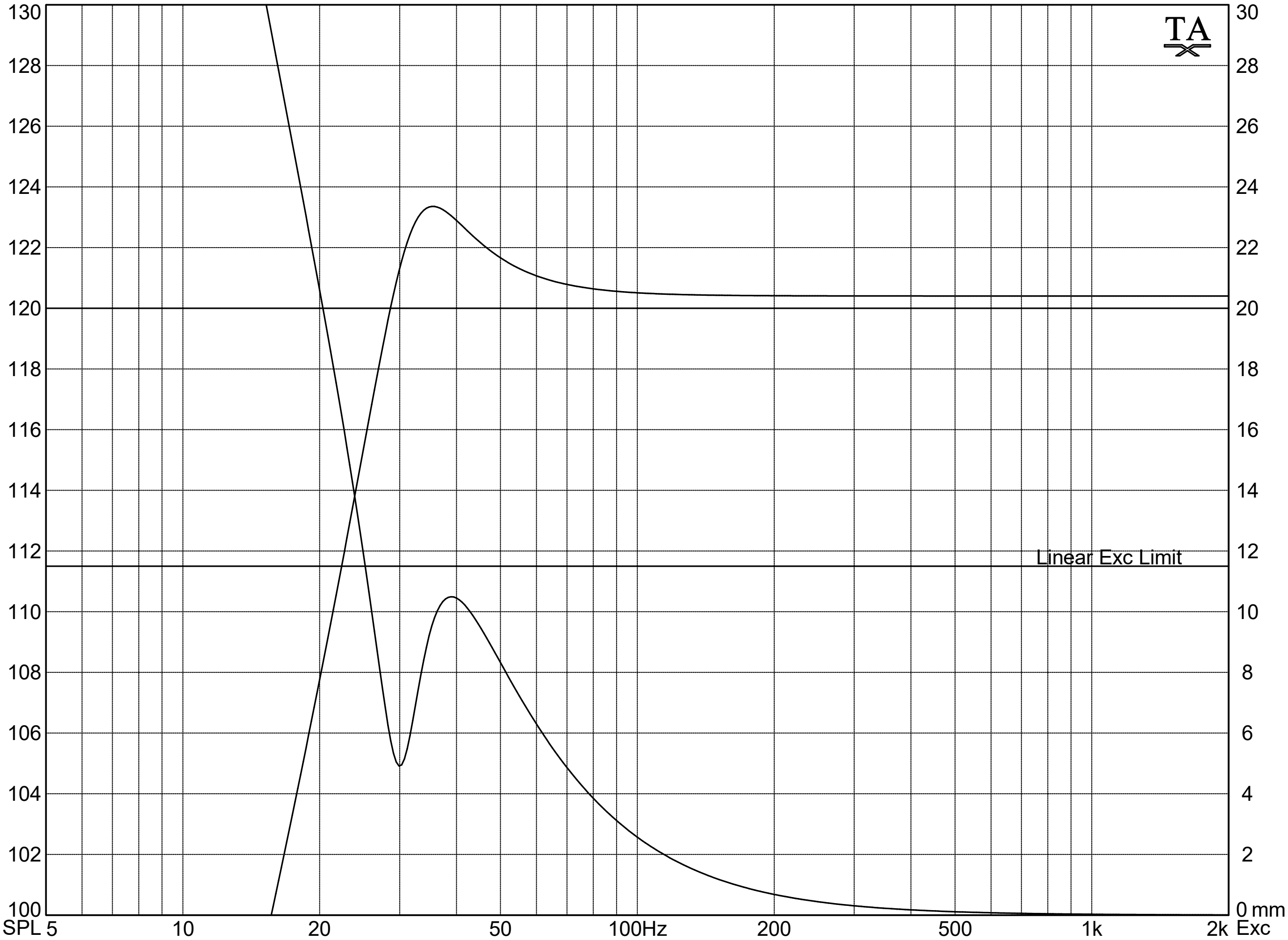
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: SB Acoustics SB42FHCL75-6

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	93	dB SPL
Free Air Resonance	f(s) =	18.4	Hz
Total Q	Q(ts) =	0.31	
Electrical Q	Q(es) =	0.32	
Mechanical Q	Q(ms) =	7.4	
Equivalent Volume	V(as) =	16.32	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	4.6	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	11.5	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	10	cu ft
Closed Box Q	Q(tc) =	0.5029	
Box Frequency	F(B) =	30	Hz
Min Rec Vent Area	S(vMin) =	36.4	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	1.632	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	550	Watts
SPL Distance	D =	1	m

My Company
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My Address, line 2
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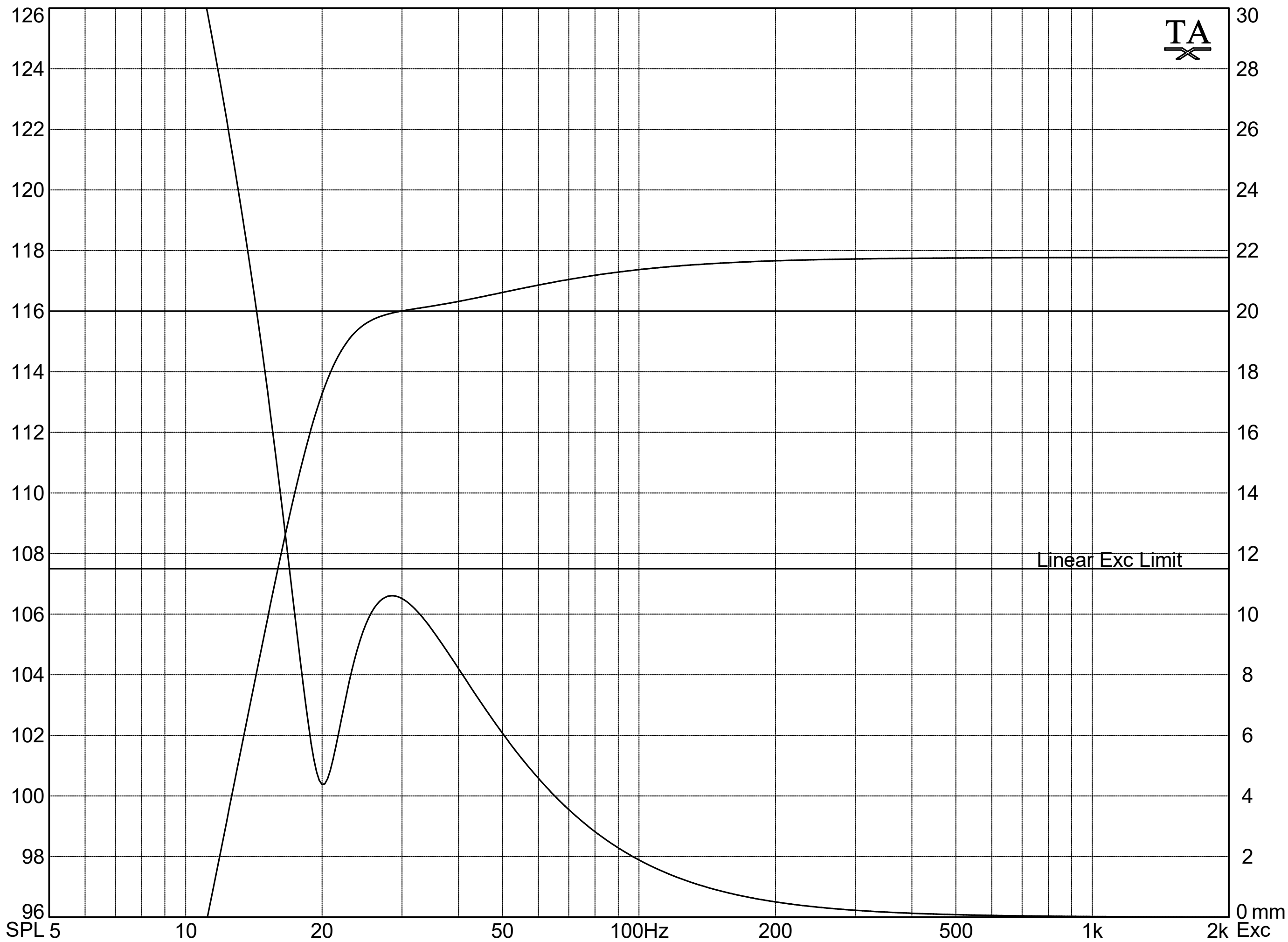
My Phone

System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: SB Acoustics SB42FHCL75-6

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	93	dB SPL
Free Air Resonance	f(s) =	18.4	Hz
Total Q	Q(ts) =	0.31	
Electrical Q	Q(es) =	0.32	
Mechanical Q	Q(ms) =	7.4	
Equivalent Volume	V(as) =	16.32	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	4.6	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	11.5	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	11	cu ft
Closed Box Q	Q(tc) =	0.4885	
Box Frequency	F(B) =	20	Hz
Min Rec Vent Area	S(vMin) =	24.2	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	1.483	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	300	Watts
SPL Distance	D =	1	m

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System Name:

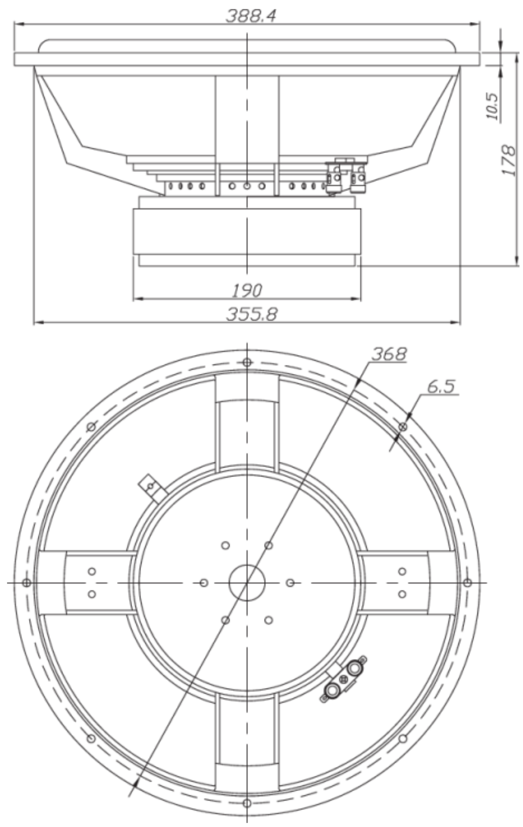
4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:

RSS390HF-4 15" Reference HF Subwoofer 4 Ohm

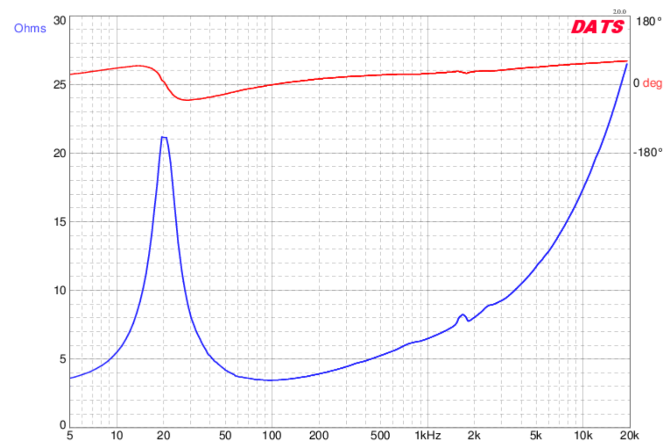
RSS390HF-4



PARAMETERS

Impedance	4 ohms
Re	3 ohms
Le	0.92 mH @ 1 kHz
Fs	19.5 Hz
Qms	3.02
Qes	0.50
Qts	0.43
Mms	306g
Cms	0.22 mm/N
Sd	829.6 cm²
Vd	1,161.4 cm³
BL	15 Tm
Vas	212 liters
Xmax	14.0 mm
VC Diameter	64 mm
SPL	91.2 dB @ 2.83V/1m
RMS Power Handling	500 watts
Usable Frequency Range (Hz)	18 - 800 Hz

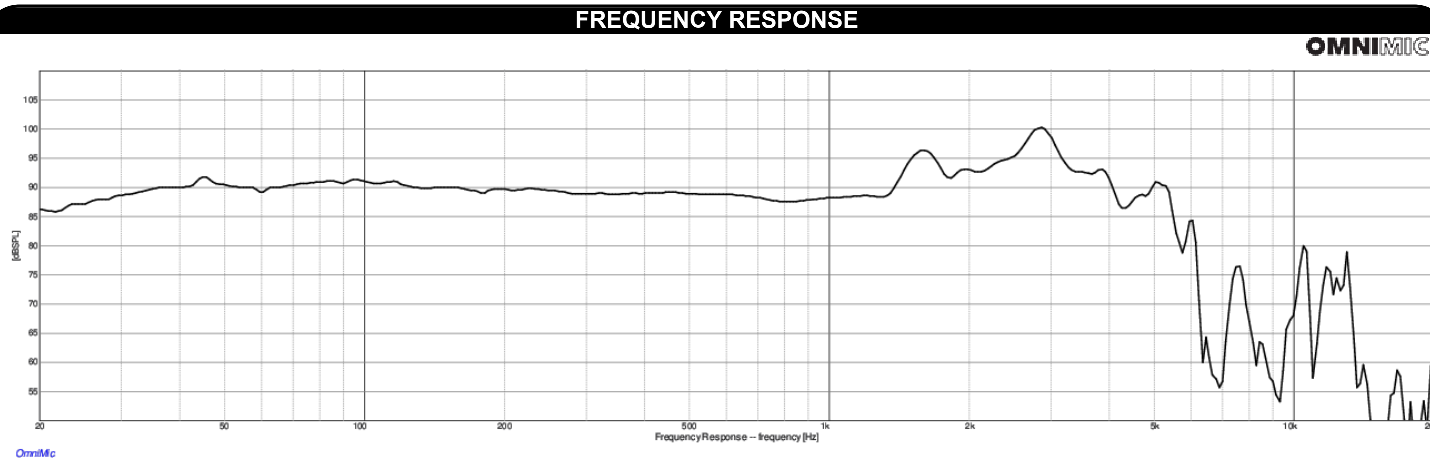
IMPEDANCE/PHASE



FEATURES

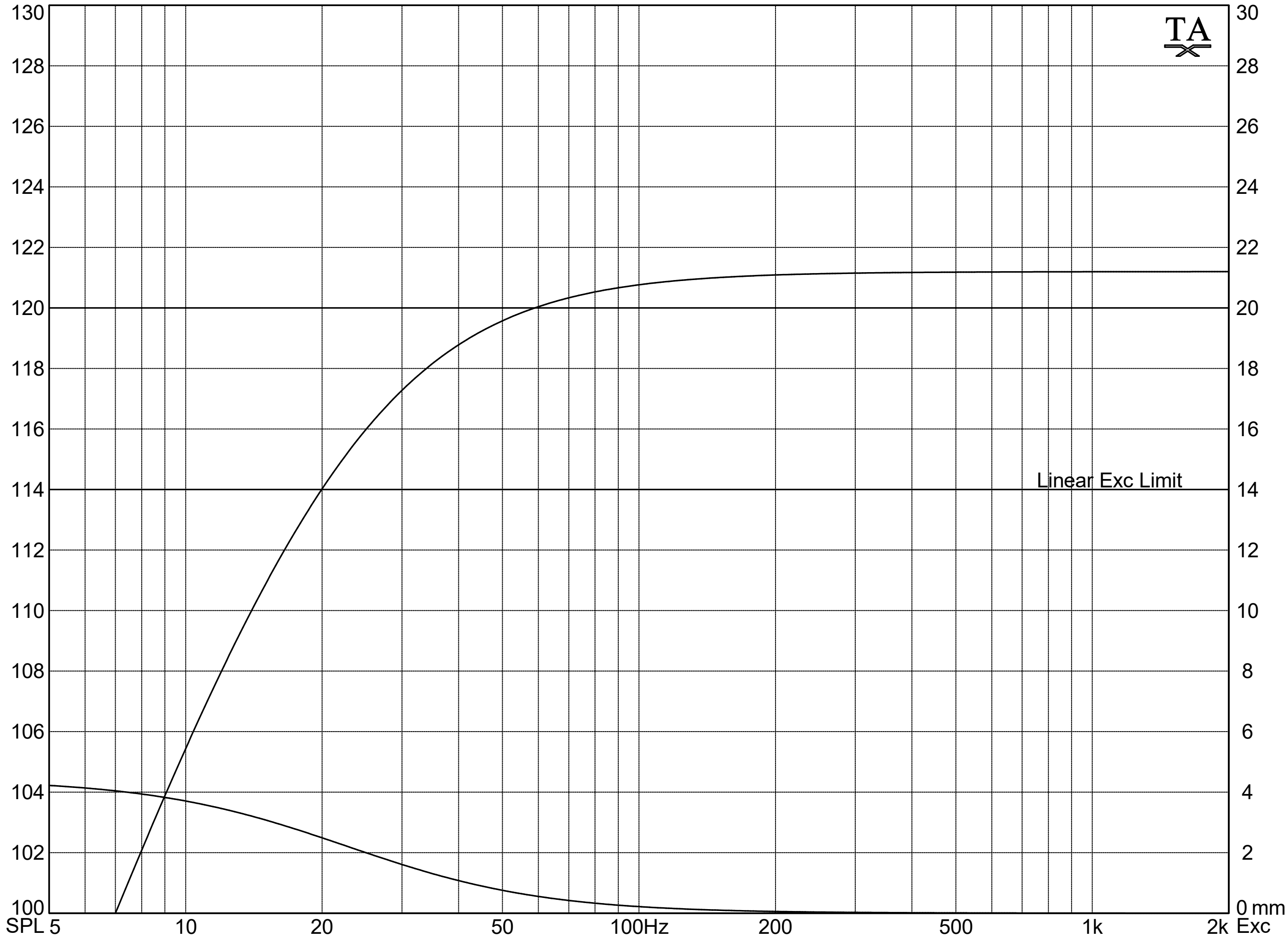
- Extensively vented motor eliminates compression and allows quiet excursion
- Lightweight black anodized aluminum cone for rigidity and lower moving mass
- Triple shorting ring motor for ultra-low distortion
- 2-layer coil for reduced back EMF
- Suitable for sealed or vented enclosures

FREQUENCY RESPONSE



Black = 0°

Note: 1/24th octave smoothing - nearfield response included in graph below 450 Hz.



Driver Parameters

DriverDayton Audio RSS390HF-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.2	dB SPL
Free Air Resonance	f(s) =	19.5	Hz
Total Q	Q(ts) =	0.43	
Electrical Q	Q(es) =	0.5	
Mechanical Q	Q(ms) =	3.02	
Equivalent Volume	V(as) =	7.487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3	Ohms
Max Thermal Power	P(t) =	500	Watts
Max Linear Excursion	X(max) =	14	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	21.26	cu ft
Closed Box Q	Q(tc) =	0.5	
System Resonance	F(sc) =	22.67	Hz
Compliance Ratio	alpha =	0.3521	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	1000	Watts
SPL Distance	D =	1	m

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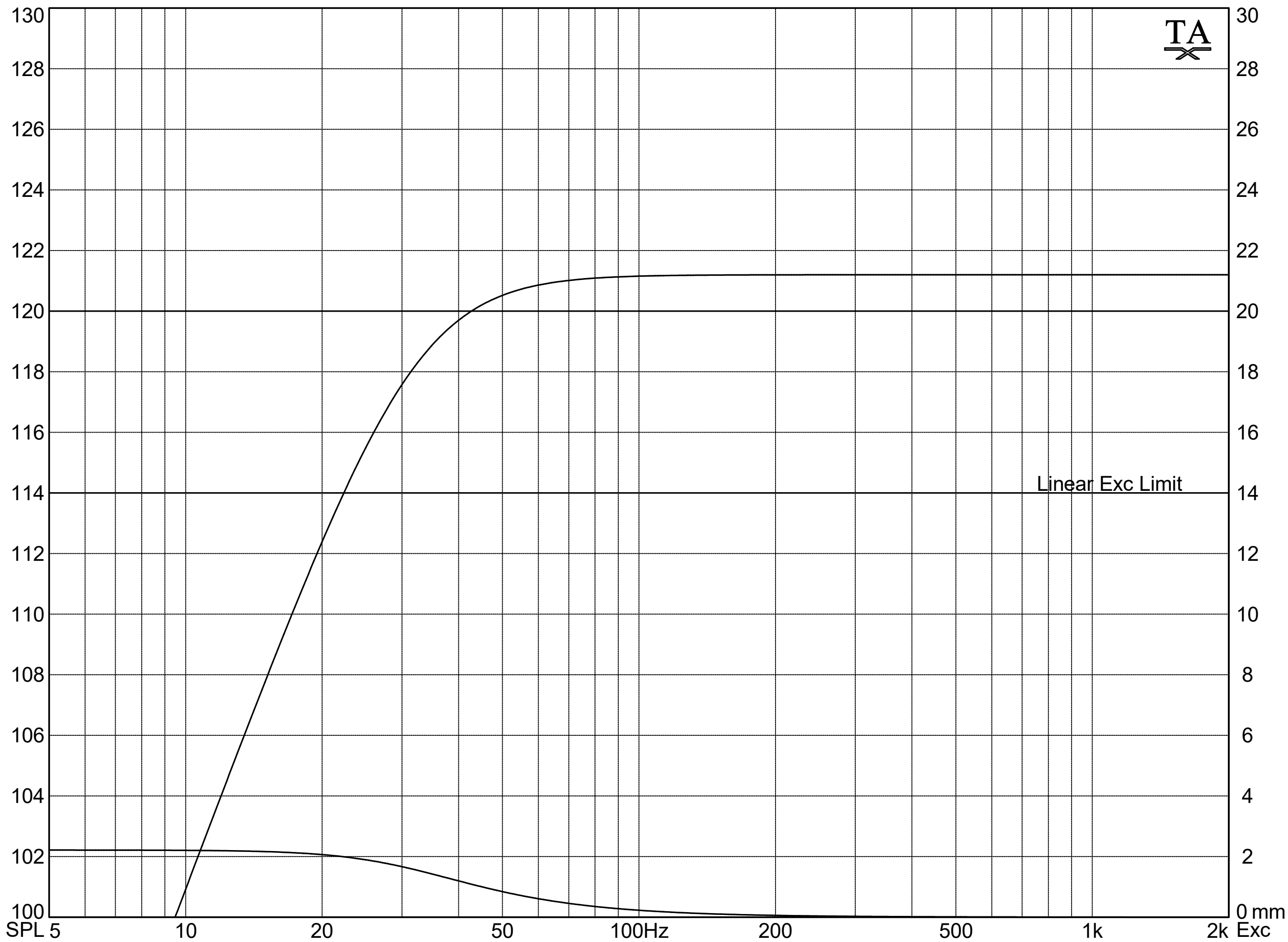
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver:Dayton Audio RSS390HF4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.2	dB SPL
Free Air Resonance	f(s) =	19.5	Hz
Total Q	Q(ts) =	0.43	
Electrical Q	Q(es) =	0.5	
Mechanical Q	Q(ms) =	3.02	
Equivalent Volume	V(as) =	7.487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3	Ohms
Max Thermal Power	P(t) =	500	Watts
Max Linear Excursion	X(max) =	14	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	4.395	cu ft
Closed Box Q	Q(tc) =	0.7069	
System Resonance	F(sc) =	32.06	Hz
Compliance Ratio	alpha =	1.703	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	1000	Watts
SPL Distance	D =	1	m

My Company
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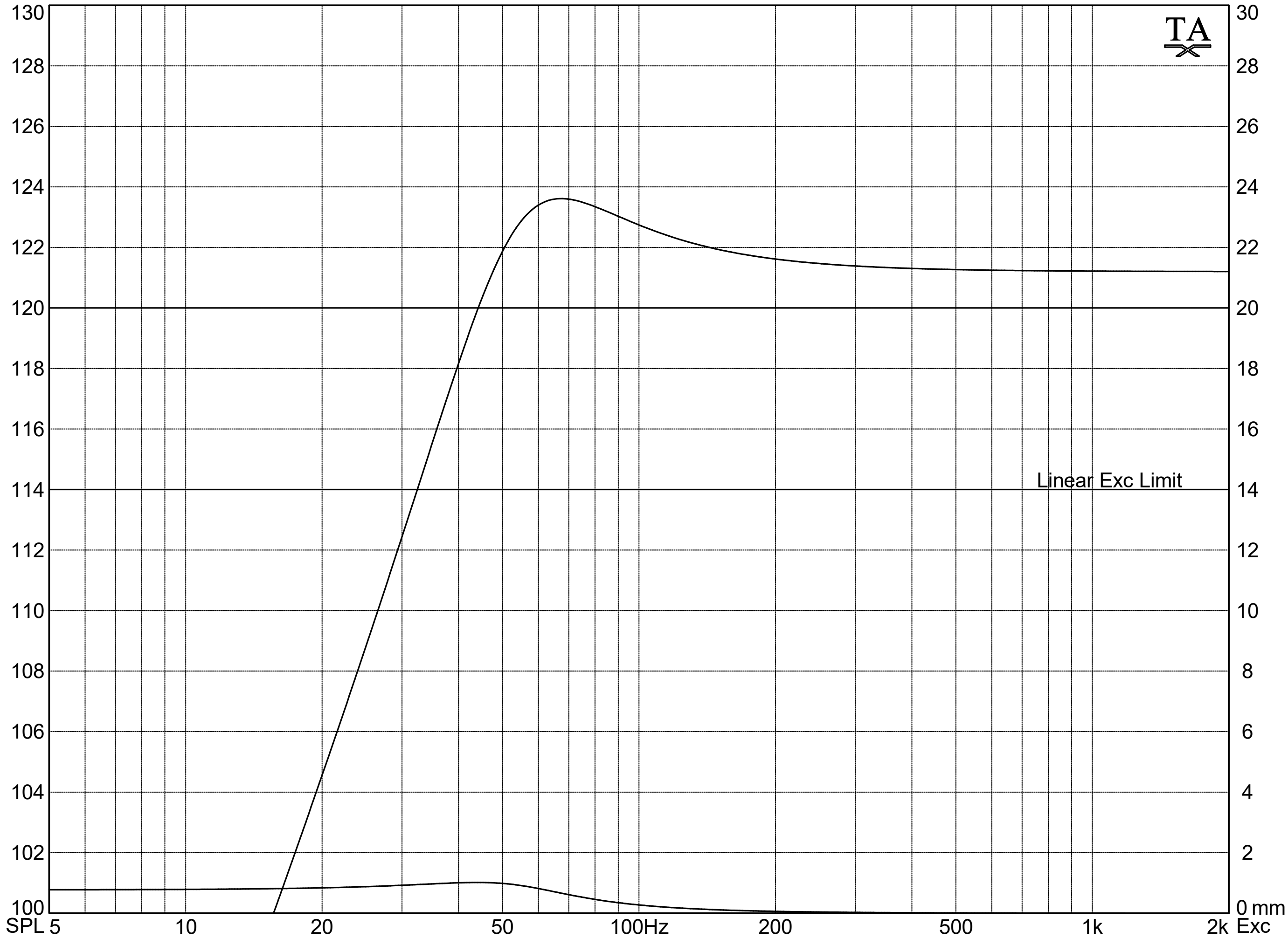
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:

Rev:



Driver Parameters

Driver:Dayton Audio RSS390HF4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.2	dB SPL
Free Air Resonance	f(s) =	19.5	Hz
Total Q	Q(ts) =	0.43	
Electrical Q	Q(es) =	0.5	
Mechanical Q	Q(ms) =	3.02	
Equivalent Volume	V(as) =	7.487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3	Ohms
Max Thermal Power	P(t) =	500	Watts
Max Linear Excursion	X(max) =	14	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	1.103	cu ft
Closed Box Q	Q(tc) =	1.2	
System Resonance	F(sc) =	54.42	Hz
Compliance Ratio	alpha =	6.788	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	1000	Watts
SPL Distance	D =	1	m

My Company

My Address, line 1
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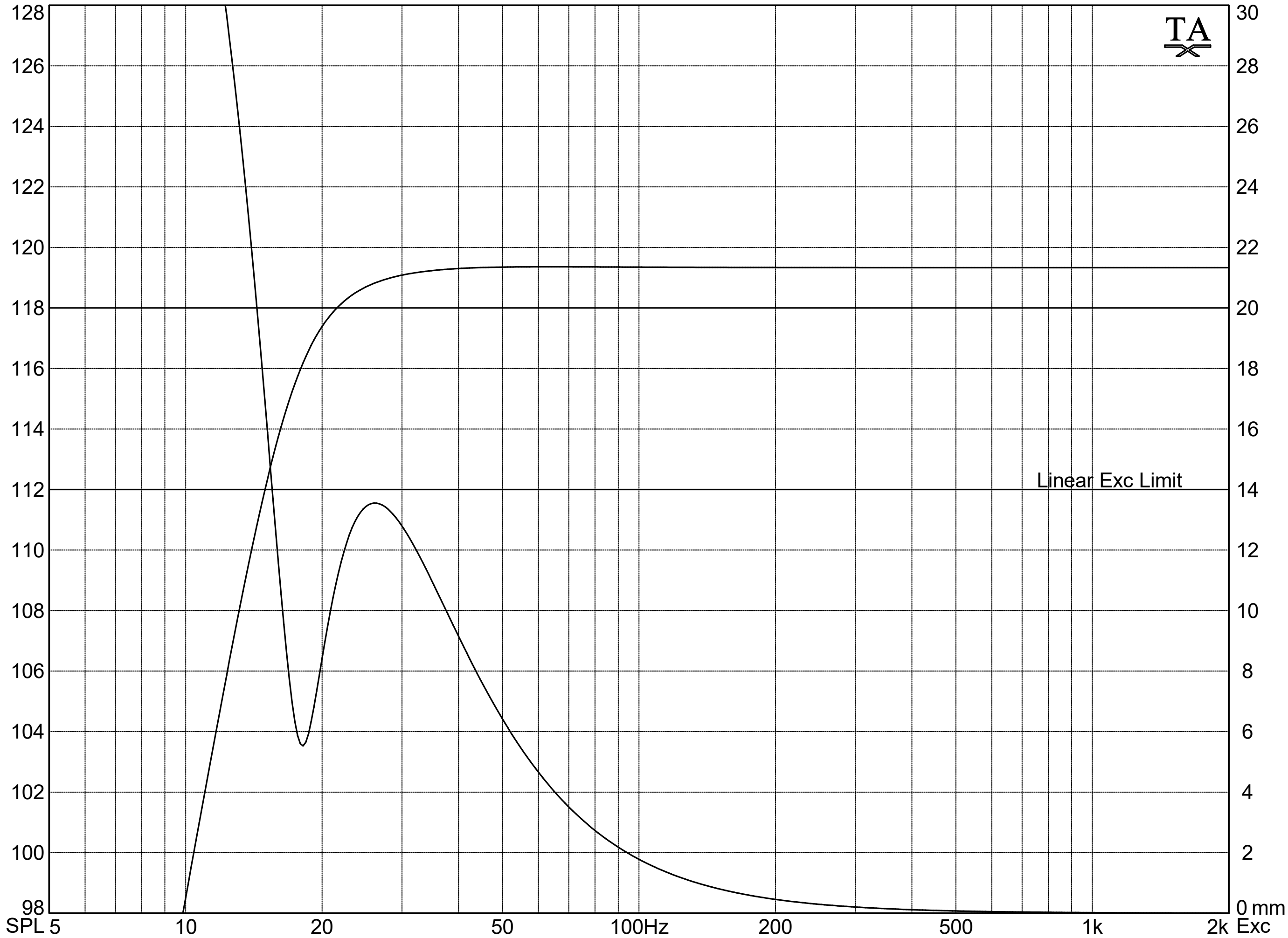
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

DriverDayton Audio RSS390HF-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.2	dB SPL
Free Air Resonance	f(s) =	19.5	Hz
Total Q	Q(ts) =	0.43	
Electrical Q	Q(es) =	0.5	
Mechanical Q	Q(ms) =	3.02	
Equivalent Volume	V(as) =	7.487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3	Ohms
Max Thermal Power	P(t) =	500	Watts
Max Linear Excursion	X(max) =	14	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	8	cu ft
Closed Box Q	Q(tc) =	0.5983	
Box Frequency	F(B) =	18	Hz
Min Rec Vent Area	S(vMin) =	25.9	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.9359	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	650	Watts
SPL Distance	D =	1	m

My Company
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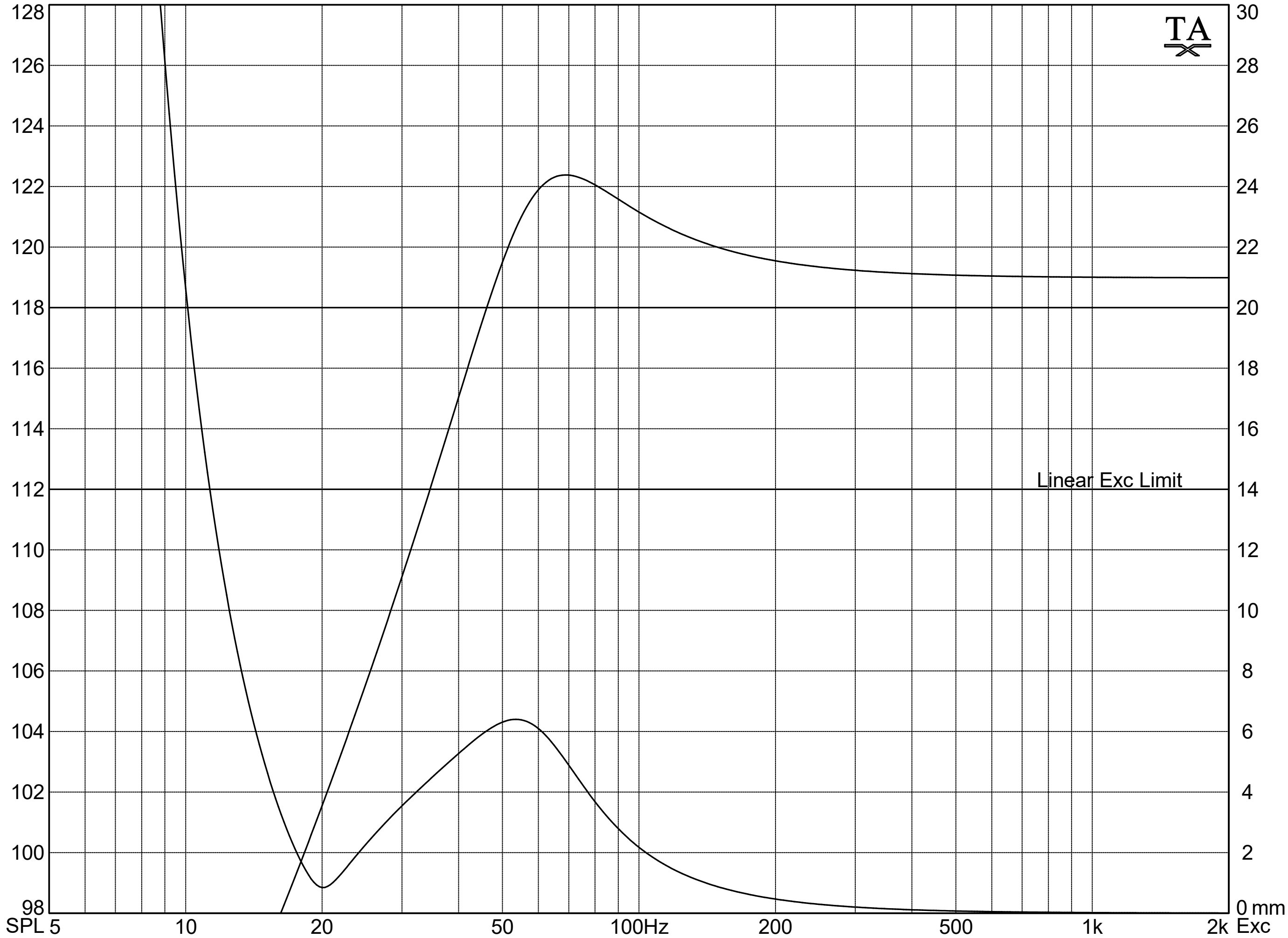
My Phone

System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

DriverDayton Audio RSS390HF-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.2	dB SPL
Free Air Resonance	f(s) =	19.5	Hz
Total Q	Q(ts) =	0.43	
Electrical Q	Q(es) =	0.5	
Mechanical Q	Q(ms) =	3.02	
Equivalent Volume	V(as) =	7.487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3	Ohms
Max Thermal Power	P(t) =	500	Watts
Max Linear Excursion	X(max) =	14	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	1	cu ft
Closed Box Q	Q(tc) =	1.253	
Box Frequency	F(B) =	20	Hz
Min Rec Vent Area	S(vMin) =	28.8	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	7.487	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	600	Watts
SPL Distance	D =	1	m

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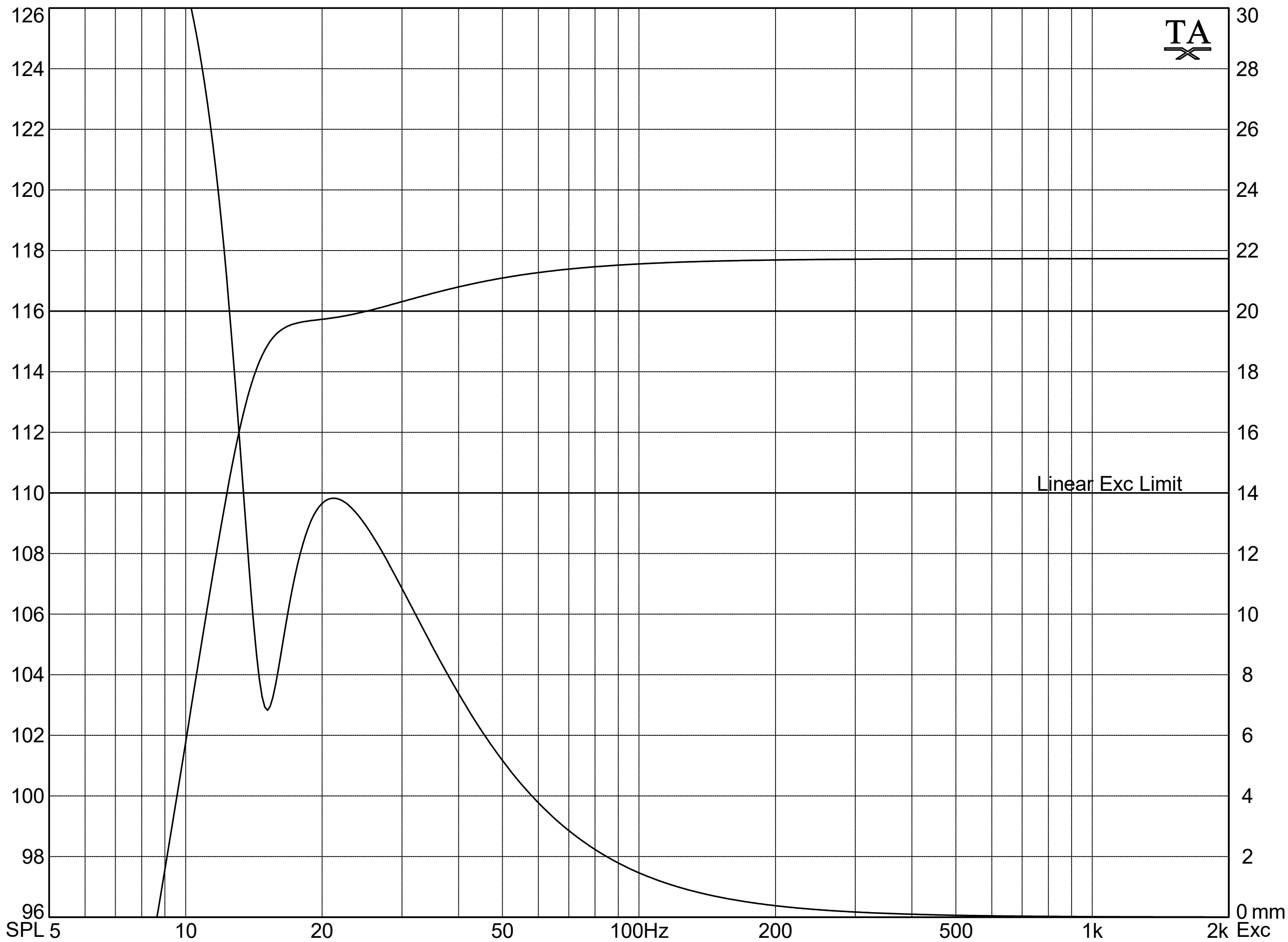
My Phone

System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

DriverDayton Audio RSS390HF-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.2	dB SPL
Free Air Resonance	f(s) =	19.5	Hz
Total Q	Q(ts) =	0.43	
Electrical Q	Q(es) =	0.5	
Mechanical Q	Q(ms) =	3.02	
Equivalent Volume	V(as) =	7.487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3	Ohms
Max Thermal Power	P(t) =	500	Watts
Max Linear Excursion	X(max) =	14	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	13	cu ft
Closed Box Q	Q(tc) =	0.5398	
Box Frequency	F(B) =	15	Hz
Min Rec Vent Area	S(vMin) =	21.6	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.5759	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	450	Watts
SPL Distance	D =	1	m

My Company
My Address, line 1
My Address, line 2
My Country My Phone

System Name:

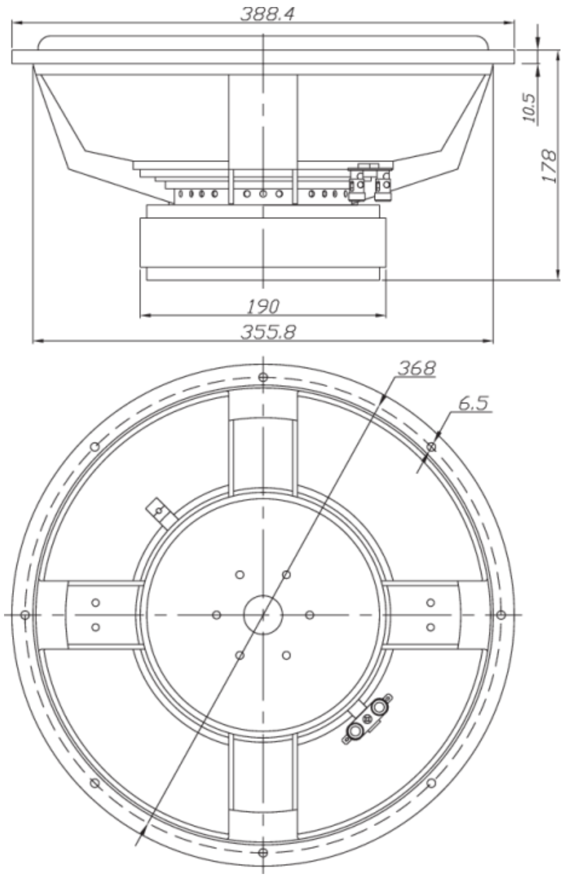
4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:

RSS390HO-4 15" Reference HO Subwoofer 4 Ohm

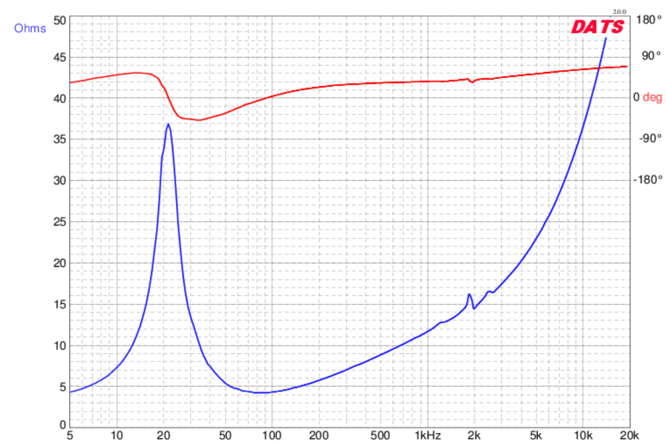
RSS390HO-4



PARAMETERS

Impedance	4 ohms
Re	3.2 ohms
Le	1.79 mH @ 1 kHz
Fs	21.5 Hz
Qms	3.69
Qes	0.35
Qts	0.32
Mms	319g
Cms	0.17 mm/N
Sd	829.6 cm²
Vd	995.5 cm³
BL	19.8 Tm
Vas	168 liters
Xmax	12.0 mm
VC Diameter	64 mm
SPL	92.8 dB @ 2.83V/1m
RMS Power Handling	800 watts
Usable Frequency Range (Hz)	21 - 600 Hz

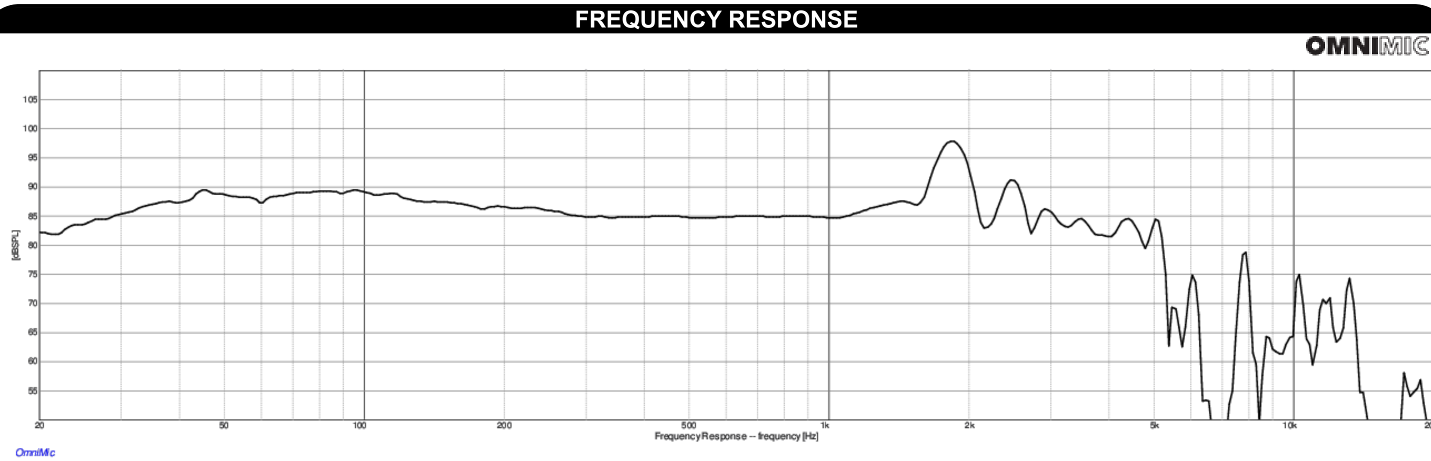
IMPEDANCE/PHASE



FEATURES

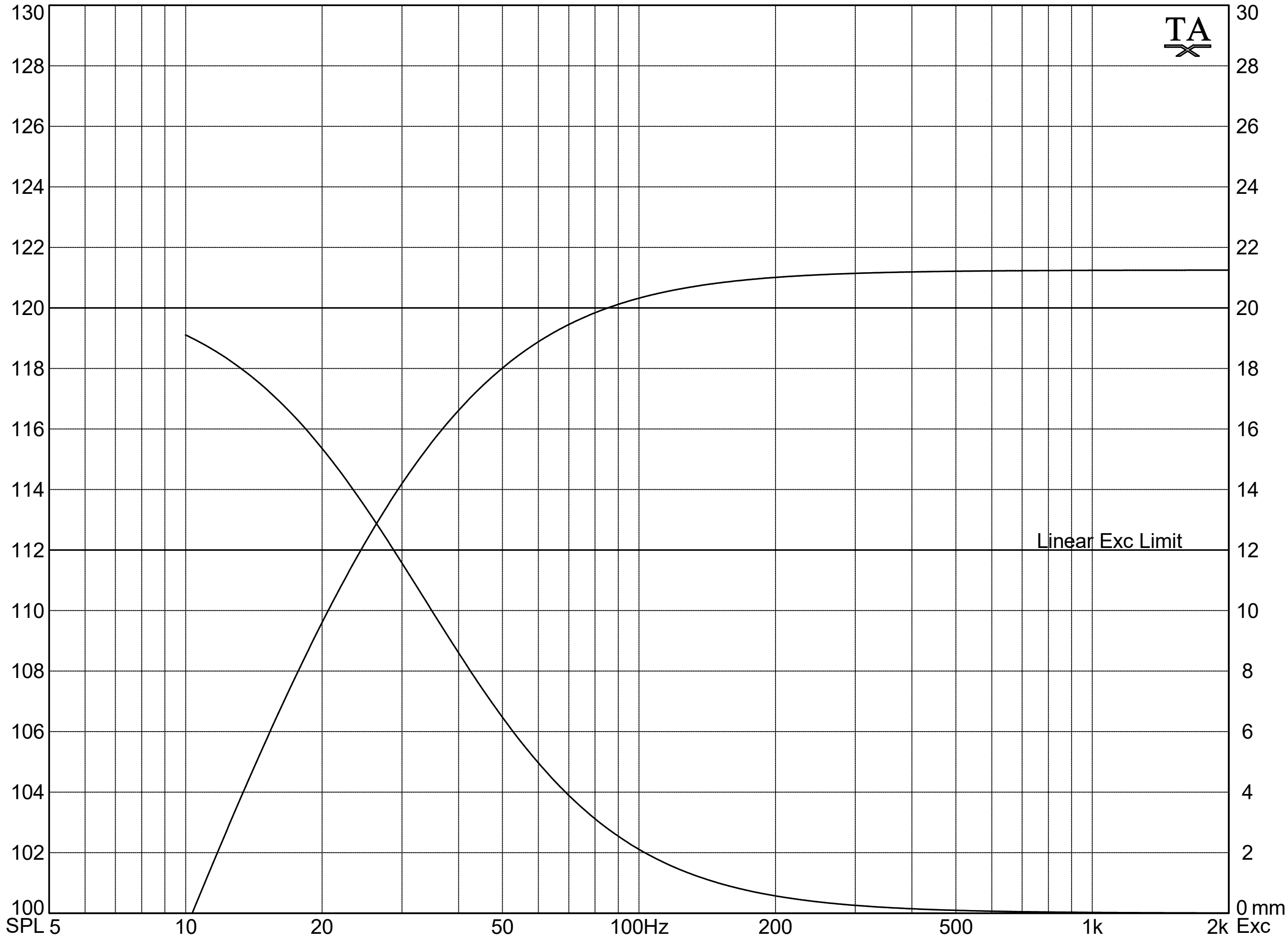
- Extensively vented motor eliminates compression and allows quiet excursion
- Lightweight black anodized aluminum cone for rigidity and lower moving mass
- Triple shorting ring motor for ultra-low distortion
- 2-layer coil for reduced back EMF
- Suitable for sealed or vented enclosures

FREQUENCY RESPONSE



Note: 1/24th octave smoothing - nearfield response included in graph below 450 Hz.

Black = 0°



Driver Parameters

Driver:Dayton Audio RSS390HO4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.8	dB SPL
Free Air Resonance	f(s) =	21.5	Hz
Total Q	Q(ts) =	0.32	
Electrical Q	Q(es) =	0.35	
Mechanical Q	Q(ms) =	3.69	
Equivalent Volume	V(as) =	5.933	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.2	Ohms
Max Thermal Power	P(t) =	800	Watts
Max Linear Excursion	X(max) =	12	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	4.116	cu ft
Closed Box Q	Q(tc) =	0.5	
System Resonance	F(sc) =	33.59	Hz
Compliance Ratio	alpha =	1.441	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	700	Watts
SPL Distance	D =	1	m

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System Name:

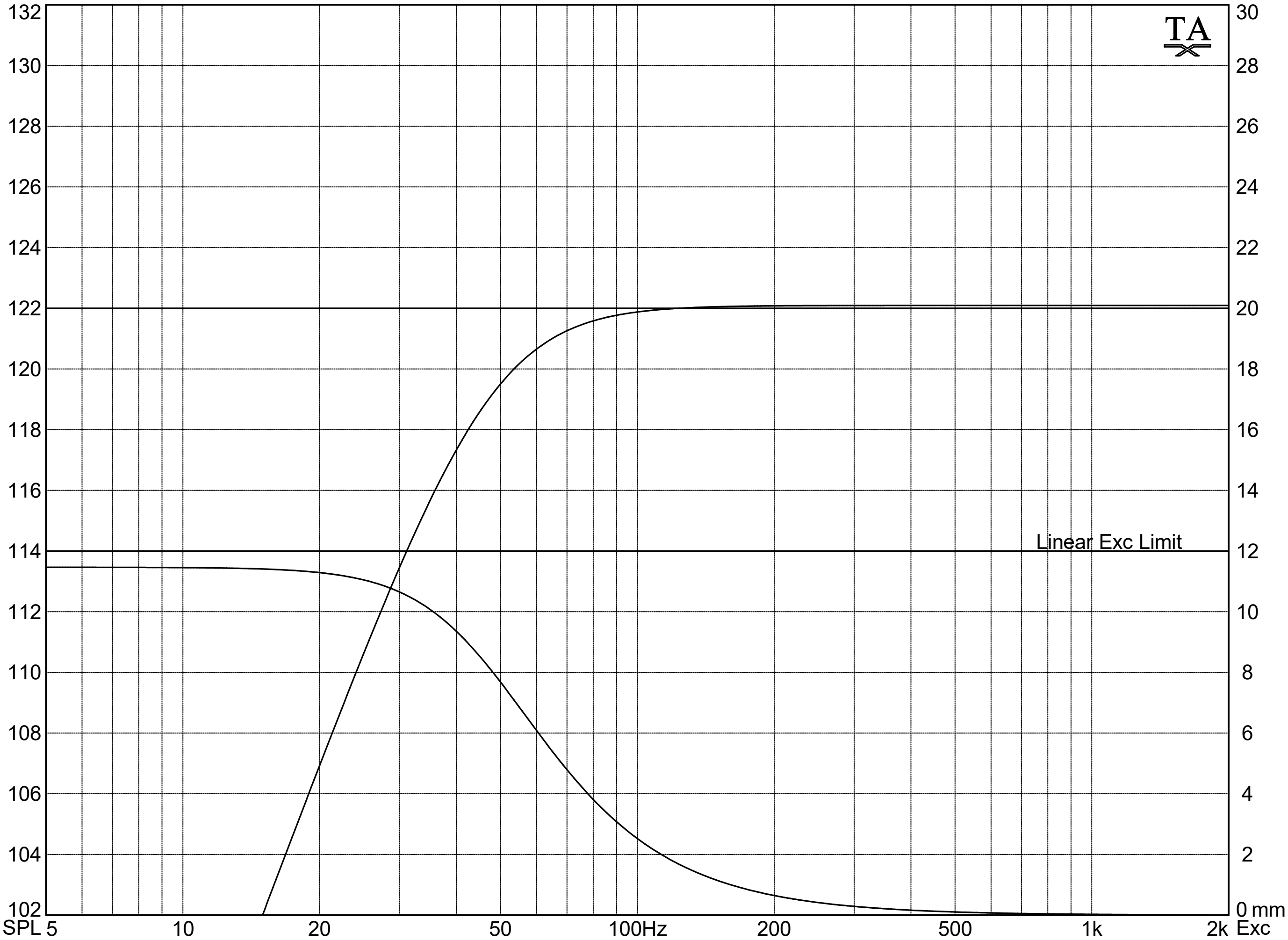
2nd Order Closed Box

Designer: Ace Hobbs

Title: Student

Rev Date:

Rev:



Driver Parameters

Driver: Dayton Audio RSS390HO4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.8	dB SPL
Free Air Resonance	f(s) =	21.5	Hz
Total Q	Q(ts) =	0.32	
Electrical Q	Q(es) =	0.35	
Mechanical Q	Q(ms) =	3.69	
Equivalent Volume	V(as) =	5.933	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.2	Ohms
Max Thermal Power	P(t) =	800	Watts
Max Linear Excursion	X(max) =	12	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	1.529	cu ft
Closed Box Q	Q(tc) =	0.707	
System Resonance	F(sc) =	47.5	Hz
Compliance Ratio	alpha =	3.882	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	850	Watts
SPL Distance	D =	1	m

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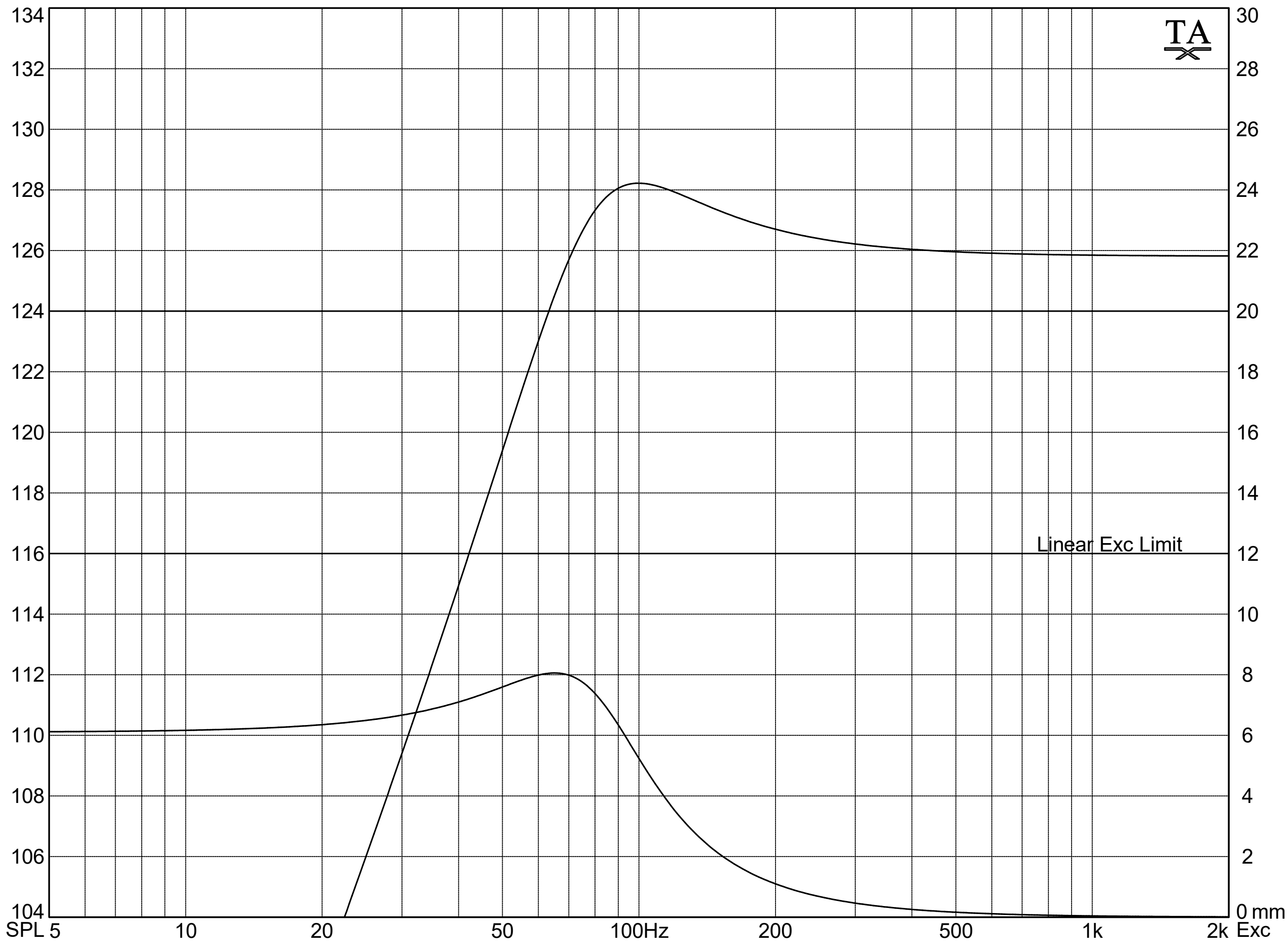
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: Dayton Audio RSS390HO4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.8	dB SPL
Free Air Resonance	f(s) =	21.5	Hz
Total Q	Q(ts) =	0.32	
Electrical Q	Q(es) =	0.35	
Mechanical Q	Q(ms) =	3.69	
Equivalent Volume	V(as) =	5.933	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.2	Ohms
Max Thermal Power	P(t) =	800	Watts
Max Linear Excursion	X(max) =	12	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	0.4542	cu ft
Closed Box Q	Q(tc) =	1.2	
System Resonance	F(sc) =	80.63	Hz
Compliance Ratio	alpha =	13.06	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	2000	Watts
SPL Distance	D =	1	m

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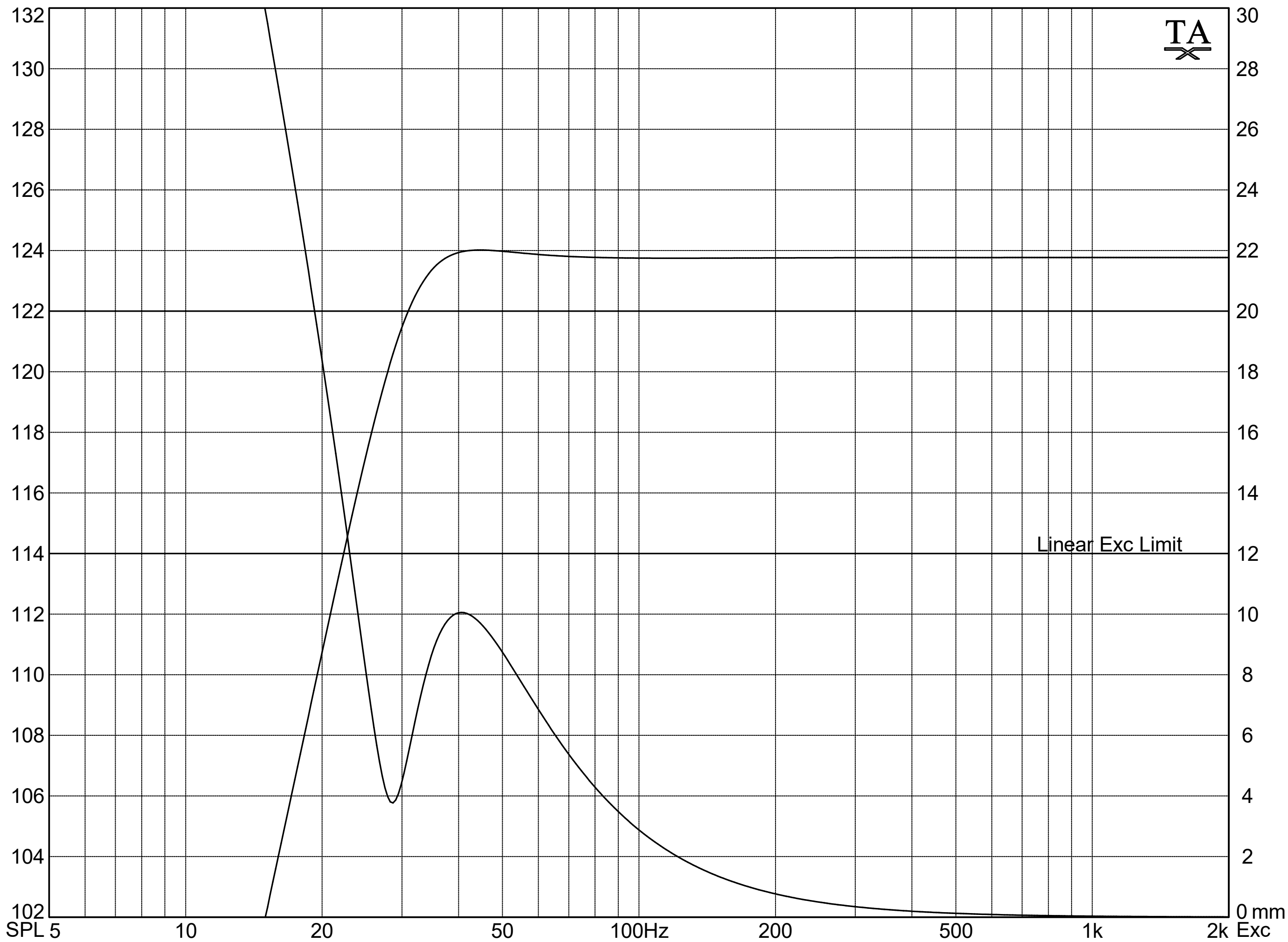
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:

Rev:



Driver Parameters

Driver:Dayton Audio RSS390HO4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.8	dB SPL
Free Air Resonance	f(s) =	21.5	Hz
Total Q	Q(ts) =	0.32	
Electrical Q	Q(es) =	0.35	
Mechanical Q	Q(ms) =	3.69	
Equivalent Volume	V(as) =	5.933	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.2	Ohms
Max Thermal Power	P(t) =	800	Watts
Max Linear Excursion	X(max) =	12	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	3	cu ft
Closed Box Q	Q(tc) =	0.5522	
Box Frequency	F(B) =	28.5	Hz
Min Rec Vent Area	S(vMin) =	35.2	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	1.978	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	1250	Watts
SPL Distance	D =	1	m

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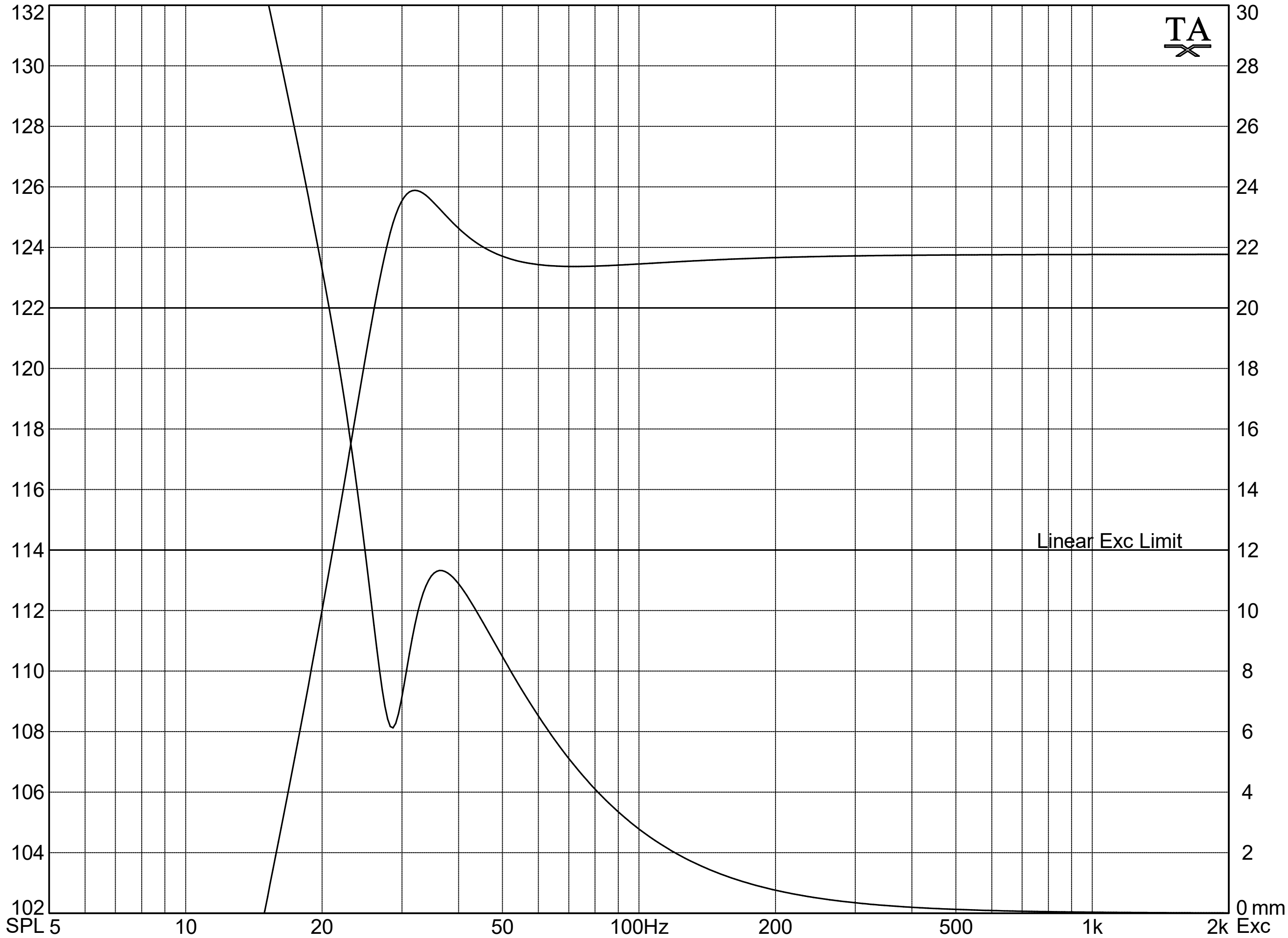
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver:Dayton Audio RSS390HO4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.8	dB SPL
Free Air Resonance	f(s) =	21.5	Hz
Total Q	Q(ts) =	0.32	
Electrical Q	Q(es) =	0.35	
Mechanical Q	Q(ms) =	3.69	
Equivalent Volume	V(as) =	5.933	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.2	Ohms
Max Thermal Power	P(t) =	800	Watts
Max Linear Excursion	X(max) =	12	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	6	cu ft
Closed Box Q	Q(tc) =	0.4513	
Box Frequency	F(B) =	28.5	Hz
Min Rec Vent Area	S(vMin) =	35.2	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.9888	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	1250	Watts
SPL Distance	D =	1	m

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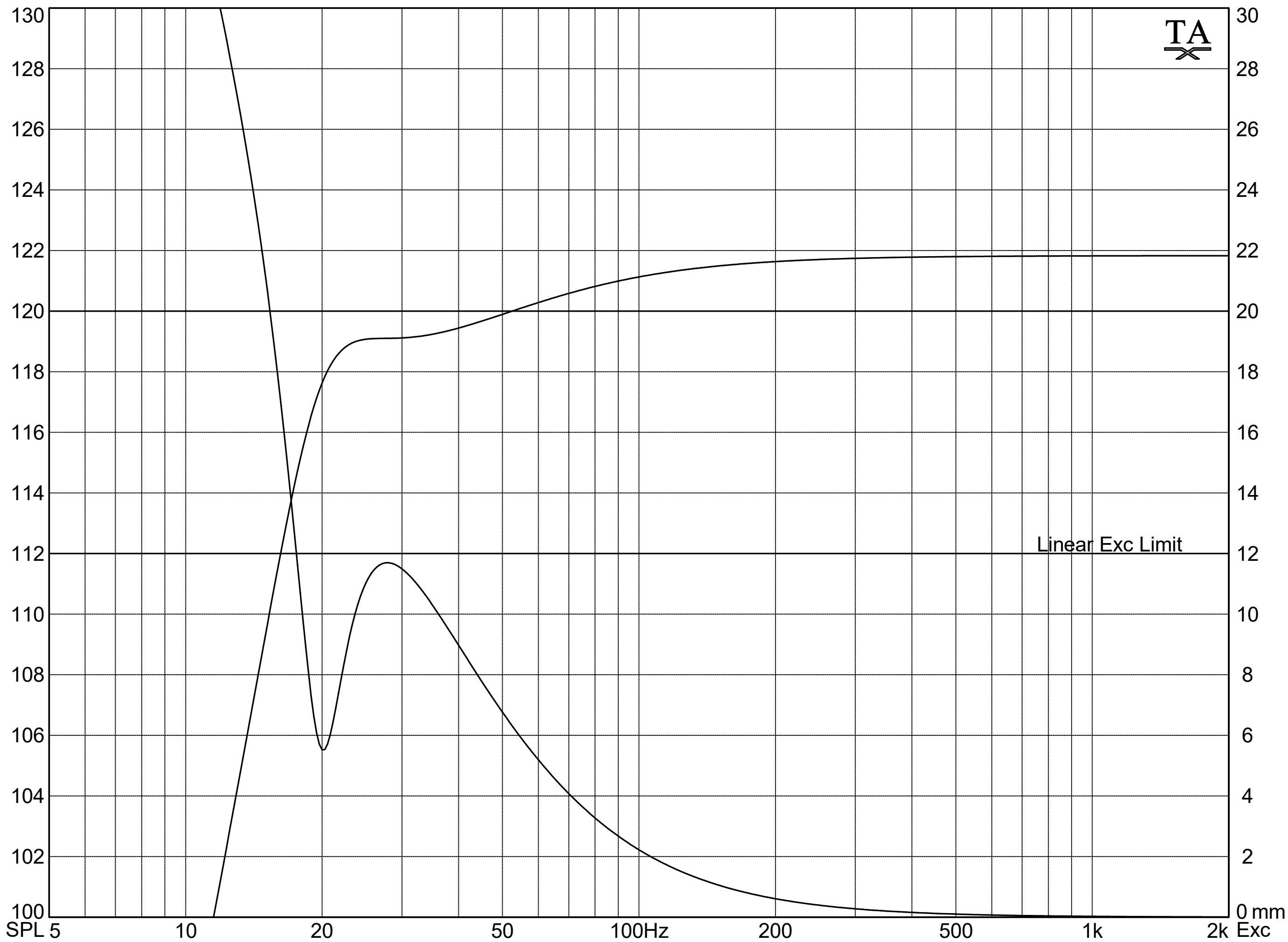
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: Dayton Audio RSS390HO4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.8	dB SPL
Free Air Resonance	f(s) =	21.5	Hz
Total Q	Q(ts) =	0.32	
Electrical Q	Q(es) =	0.35	
Mechanical Q	Q(ms) =	3.69	
Equivalent Volume	V(as) =	5.933	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.2	Ohms
Max Thermal Power	P(t) =	800	Watts
Max Linear Excursion	X(max) =	12	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	6	cu ft
Closed Box Q	Q(tc) =	0.4513	
Box Frequency	F(B) =	20	Hz
Min Rec Vent Area	S(vMin) =	24.7	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.9888	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	800	Watts
SPL Distance	D =	1	m

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System Name:

4th Order Vented Box

Designer: Ace Hobbs

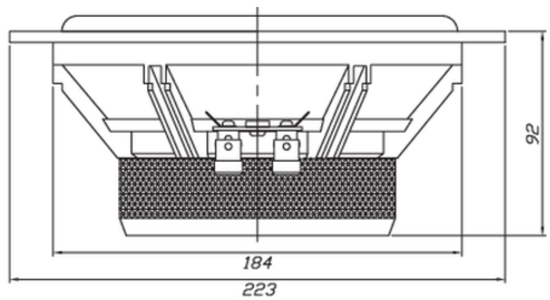
Title: Student

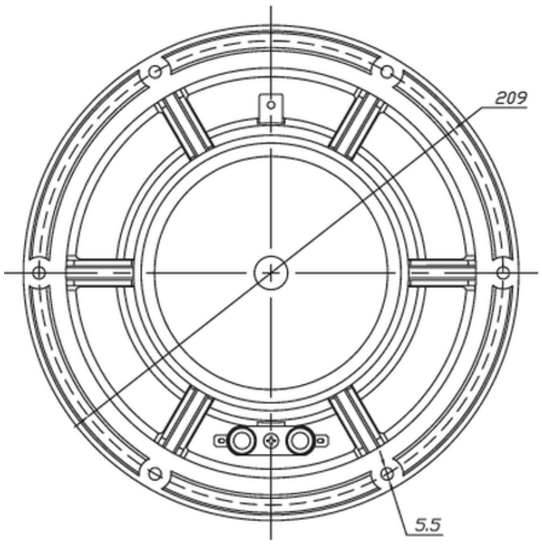
Rev Date:

Rev:

RS225-4 8" Reference Woofer 4 Ohm

RS225-4

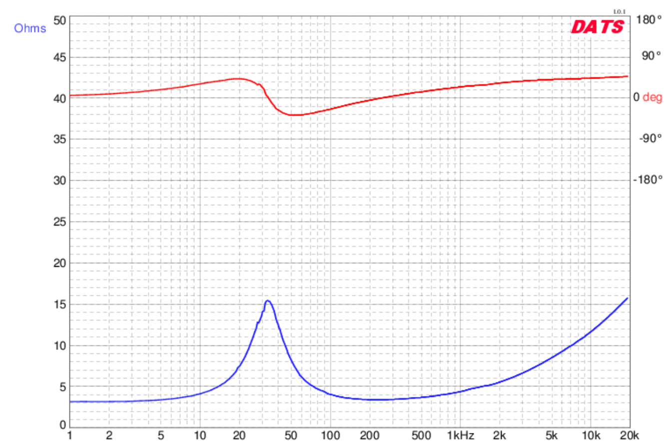




PARAMETERS

Impedance	4 ohms
Re	3.2 ohms
Le	0.49 mH @ 1 kHz
Fs	33 Hz
Qms	2.02
Qes	0.52
Qts	0.41
Mms	32.2g
Cms	0.72 mm/N
Sd	213.8 cm²
Vd	128.2 cm³
BL	6.38 Tm
Vas	46.4 liters
Xmax	6.0 mm
VC Diameter	38 mm
SPL	91 dB @ 2.83V/1m
RMS Power Handling	80 watts
Usable Frequency Range (Hz)	35 - 2,300 Hz

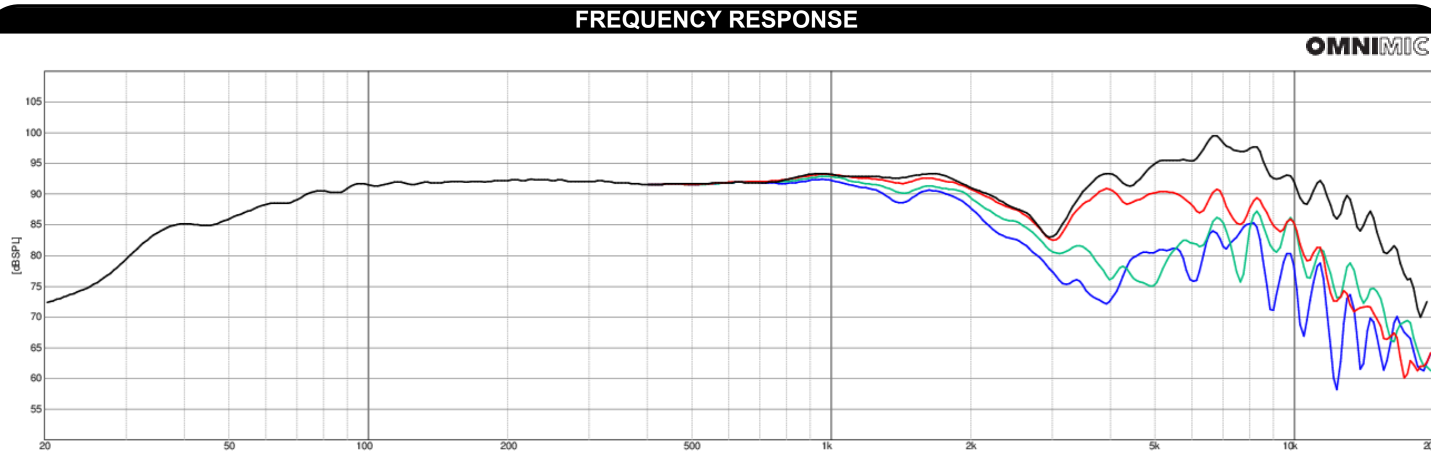
IMPEDANCE/PHASE



FEATURES

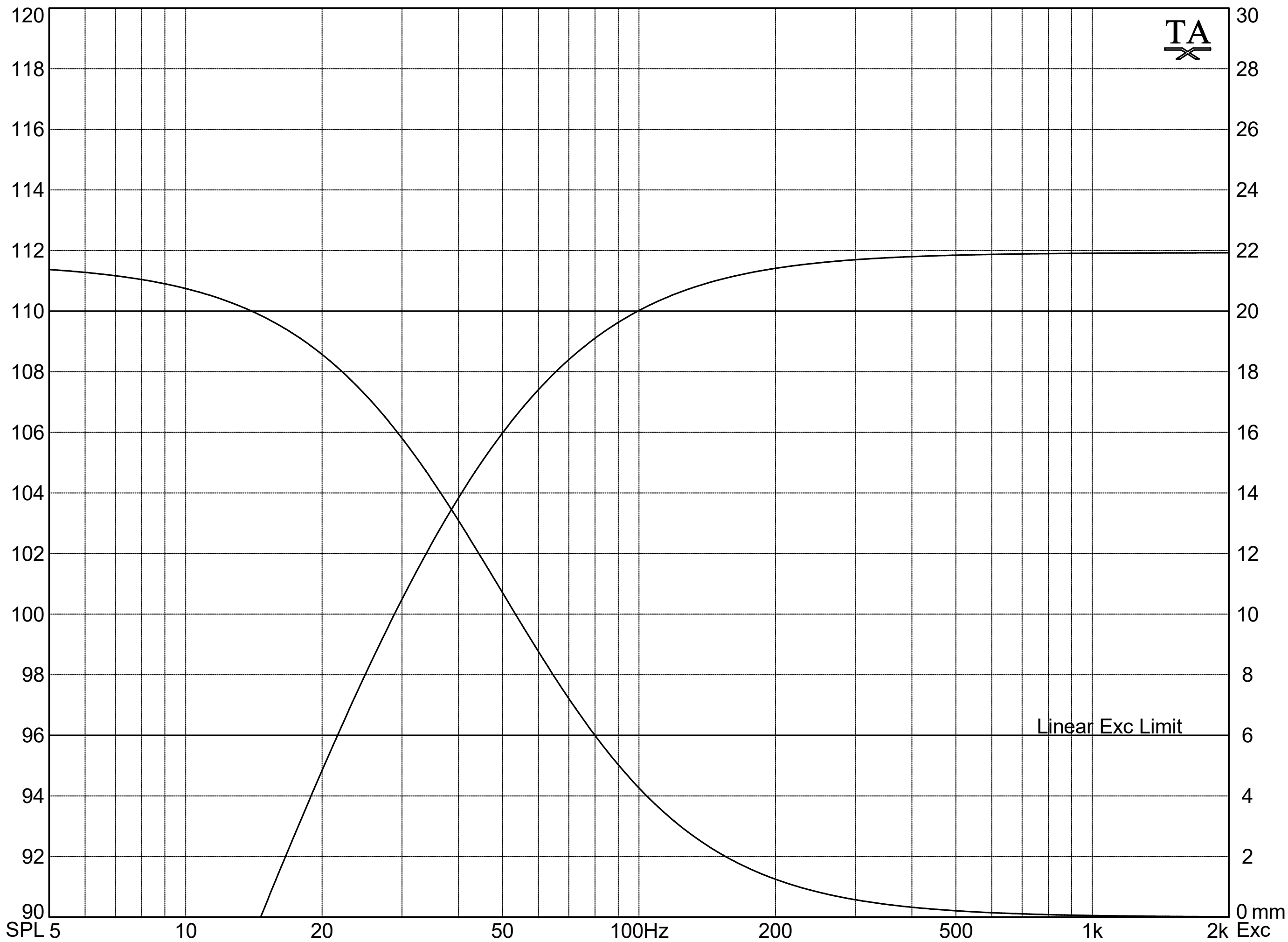
- 4 ohm impedance is perfect for series pairs in MTMs and center channel speakers
- Excellent car audio midrange/midbass
- High-end low-distortion motor with two shorting paths to reduce inductance

FREQUENCY RESPONSE



Note: 1/24th octave smoothing - nearfield response included in graph below 450 Hz.

Black = 0°
Red = 15°
Green = 30°
Blue = 45°



Driver Parameters

Driver: **Dayton Audio RS225P-4A**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.9	dB SPL
Free Air Resonance	f(s) =	37.7	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.48	
Mechanical Q	Q(ms) =	1.85	
Equivalent Volume	V(as) =	1.617	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.3	Ohms
Max Thermal Power	P(t) =	80	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	2.212	cu ft
Closed Box Q	Q(tc) =	0.5	
System Resonance	F(sc) =	49.6	Hz
Compliance Ratio	alpha =	0.7313	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	80	Watts
SPL Distance	D =	1	m

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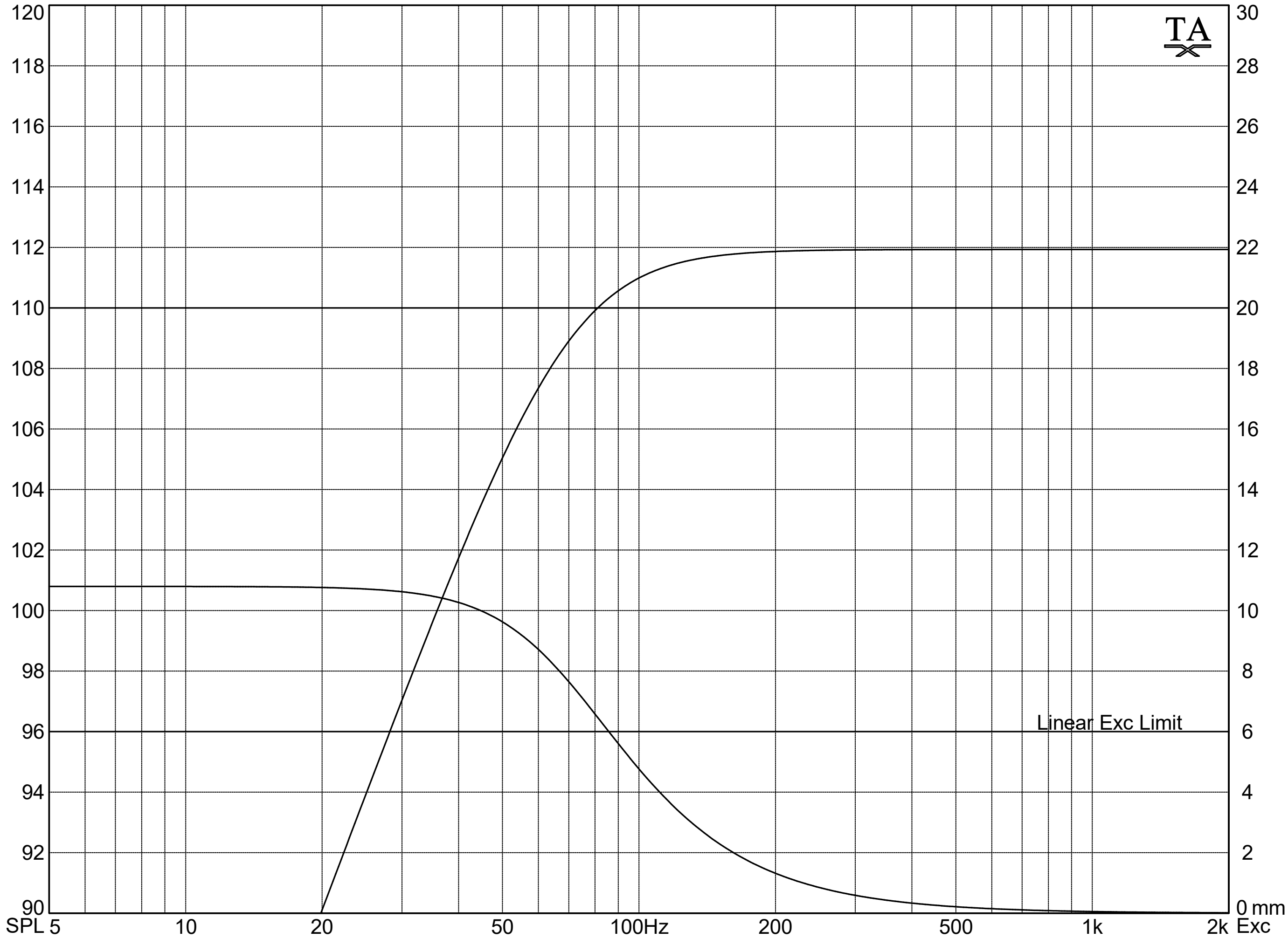
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: **Dayton Audio RS225P-4A**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.9	dB SPL
Free Air Resonance	f(s) =	37.7	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.48	
Mechanical Q	Q(ms) =	1.85	
Equivalent Volume	V(as) =	1.617	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.3	Ohms
Max Thermal Power	P(t) =	80	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	0.6571	cu ft
Closed Box Q	Q(tc) =	0.707	
System Resonance	F(sc) =	70.14	Hz
Compliance Ratio	alpha =	2.461	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	80	Watts
SPL Distance	D =	1	m

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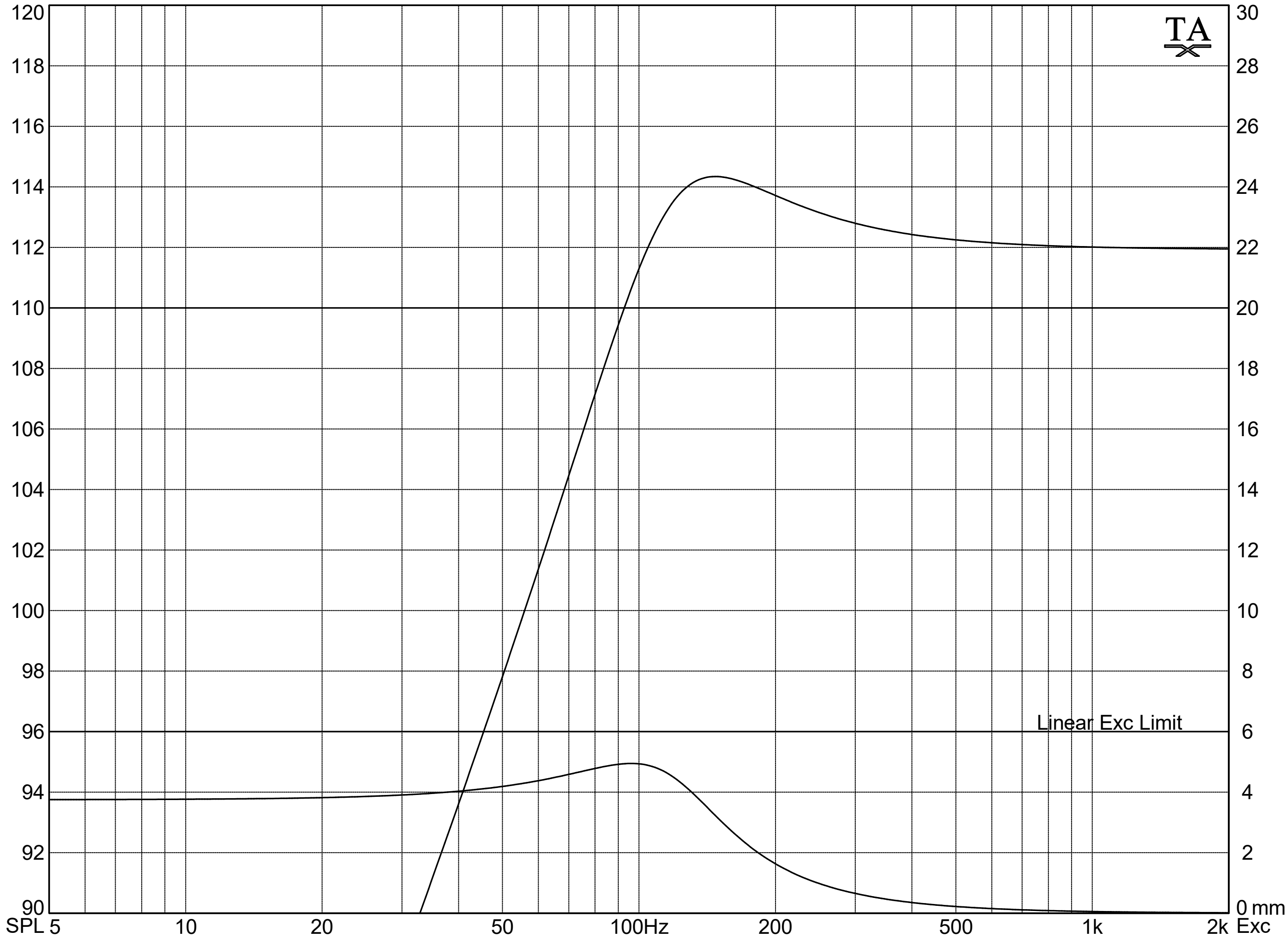
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS225P-4A**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.9	dB SPL
Free Air Resonance	f(s) =	37.7	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.48	
Mechanical Q	Q(ms) =	1.85	
Equivalent Volume	V(as) =	1.617	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.3	Ohms
Max Thermal Power	P(t) =	80	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	0.1803	cu ft
Closed Box Q	Q(tc) =	1.2	
System Resonance	F(sc) =	119	Hz
Compliance Ratio	alpha =	8.972	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	80	Watts
SPL Distance	D =	1	m

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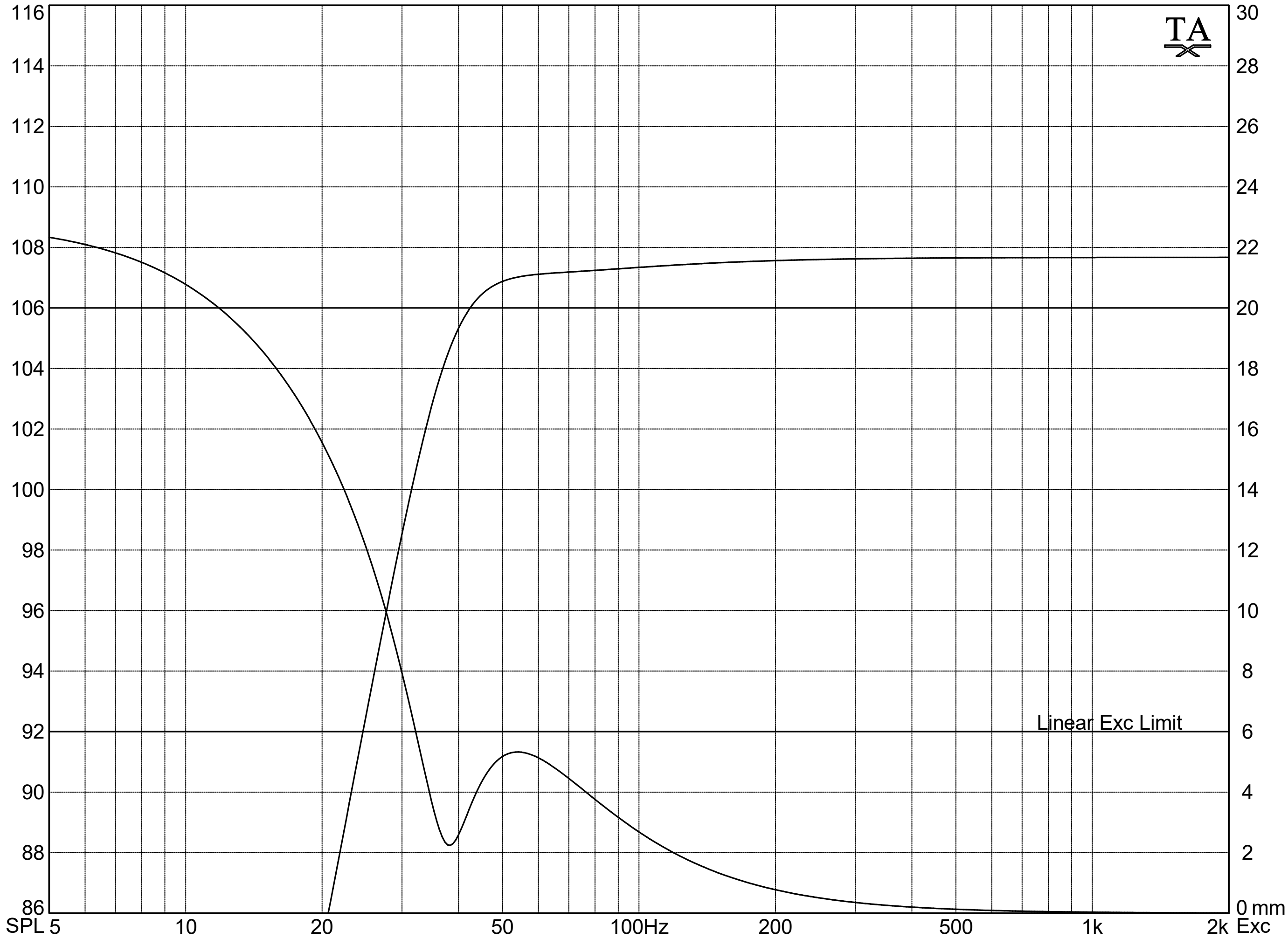
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:

Rev:



Driver Parameters

Driver: **Dayton Audio RS225P-4A**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.9	dB SPL
Free Air Resonance	f(s) =	37.7	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.48	
Mechanical Q	Q(ms) =	1.85	
Equivalent Volume	V(as) =	1.617	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.3	Ohms
Max Thermal Power	P(t) =	80	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	1.5	cu ft
Closed Box Q	Q(tc) =	0.5478	
Box Frequency	F(B) =	38	Hz
Min Rec Vent Area	S(vMin) =	3.62	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	1.078	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	30	Watts
SPL Distance	D =	1	m

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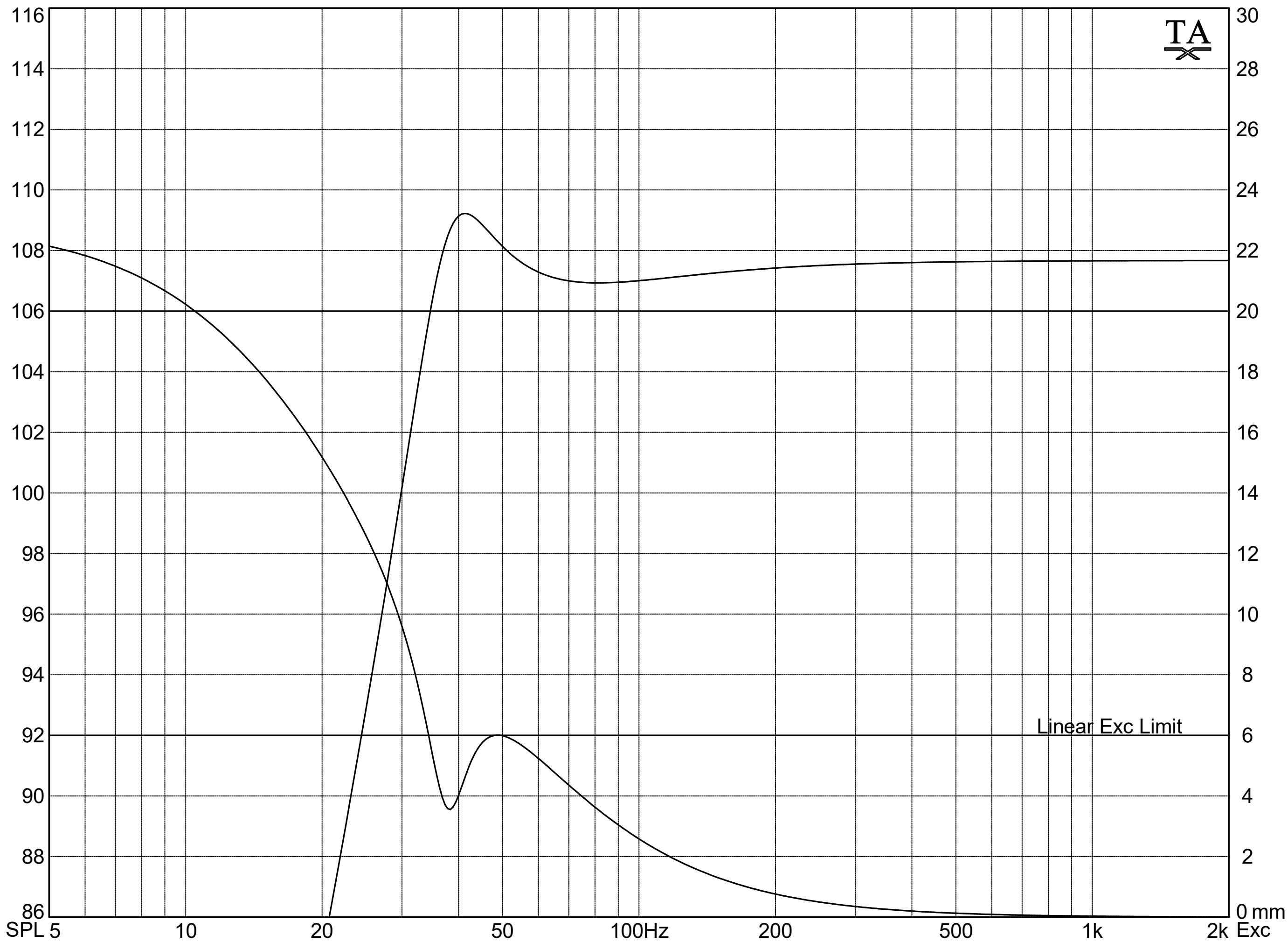
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS225P-4A**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.9	dB SPL
Free Air Resonance	f(s) =	37.7	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.48	
Mechanical Q	Q(ms) =	1.85	
Equivalent Volume	V(as) =	1.617	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.3	Ohms
Max Thermal Power	P(t) =	80	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	3	cu ft
Closed Box Q	Q(tc) =	0.4714	
Box Frequency	F(B) =	38	Hz
Min Rec Vent Area	S(vMin) =	3.62	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.5391	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	30	Watts
SPL Distance	D =	1	m

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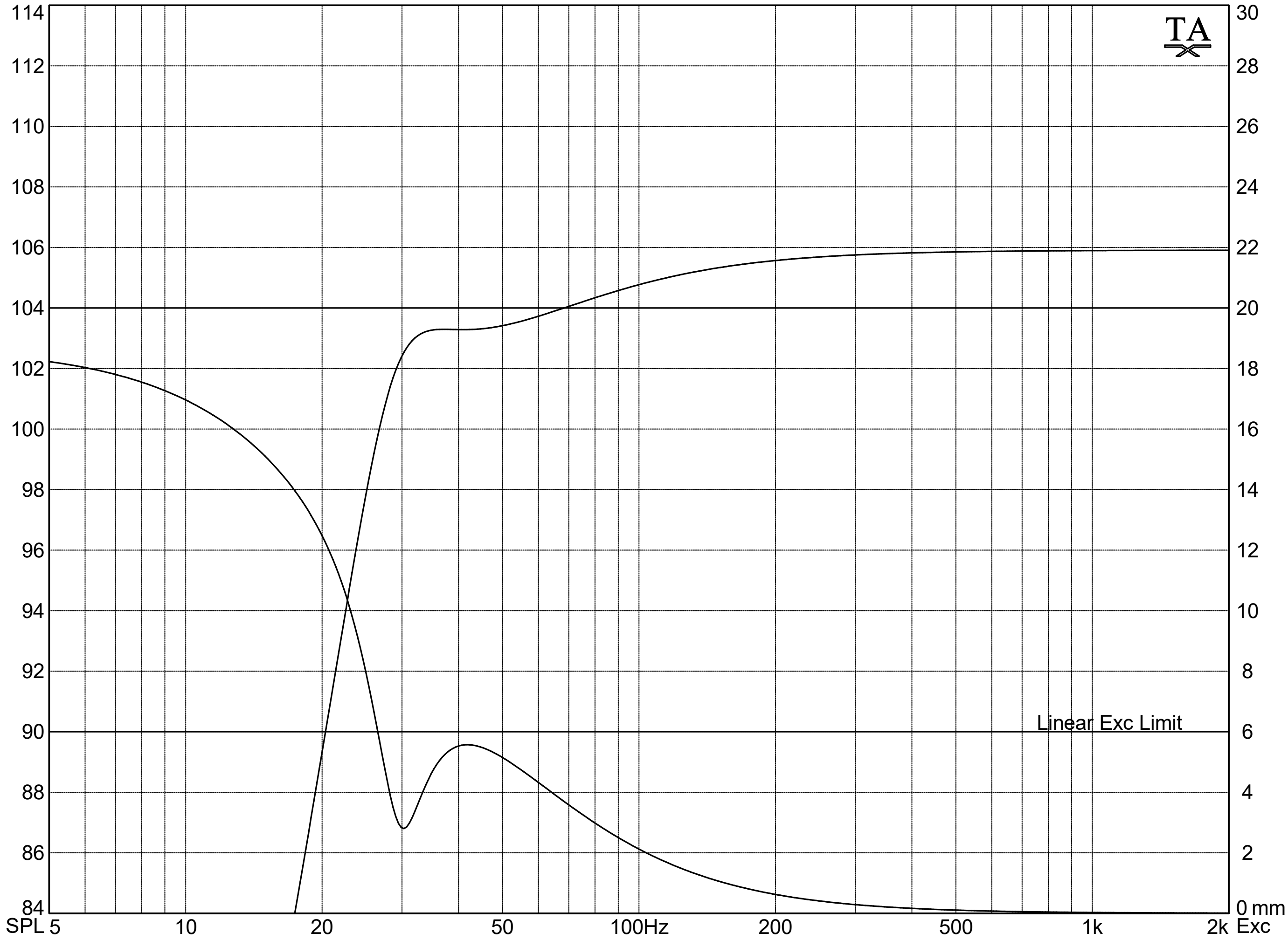
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS225P-4A**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	92.9	dB SPL
Free Air Resonance	f(s) =	37.7	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.48	
Mechanical Q	Q(ms) =	1.85	
Equivalent Volume	V(as) =	1.617	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	3.3	Ohms
Max Thermal Power	P(t) =	80	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	2.5	cu ft
Closed Box Q	Q(tc) =	0.4877	
Box Frequency	F(B) =	30	Hz
Min Rec Vent Area	S(vMin) =	2.86	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.647	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	20	Watts
SPL Distance	D =	1	m

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System Name:

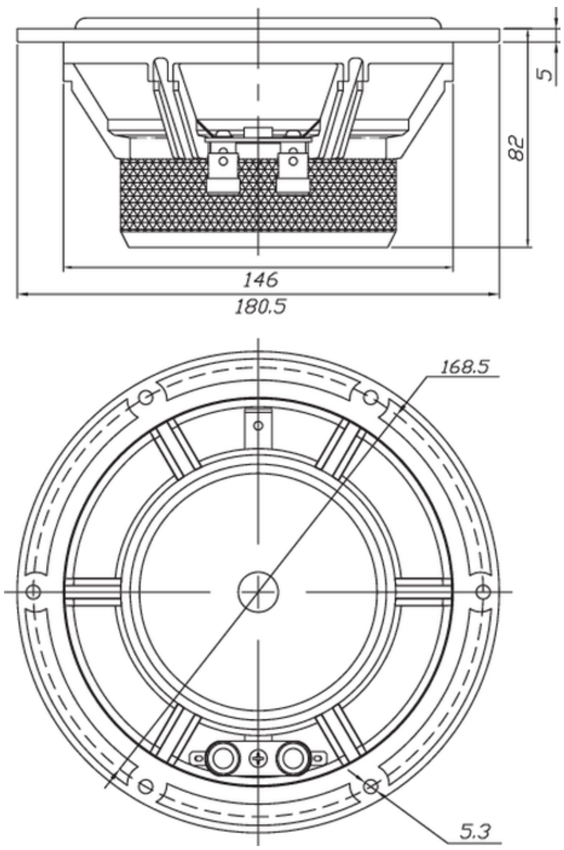
4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:

RS180-4 7" Reference Woofer 4 Ohm

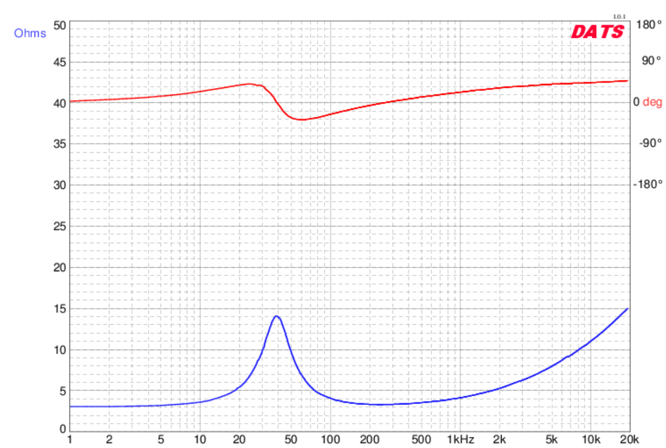
RS180-4



PARAMETERS

Impedance	4 ohms
Re	3.1 ohms
Le	0.45 mH @ 1 kHz
Fs	38.4 Hz
Qms	2.13
Qes	0.59
Qts	0.46
Mms	17.8g
Cms	0.97 mm/N
Sd	124.7 cm²
Vd	74.8 cm³
BL	4.71 Tm
Vas	21.2 liters
Xmax	6.0 mm
VC Diameter	38 mm
SPL	89.2 dB @ 2.83V/1m
RMS Power Handling	60 watts
Usable Frequency Range (Hz)	39 - 3,600 Hz

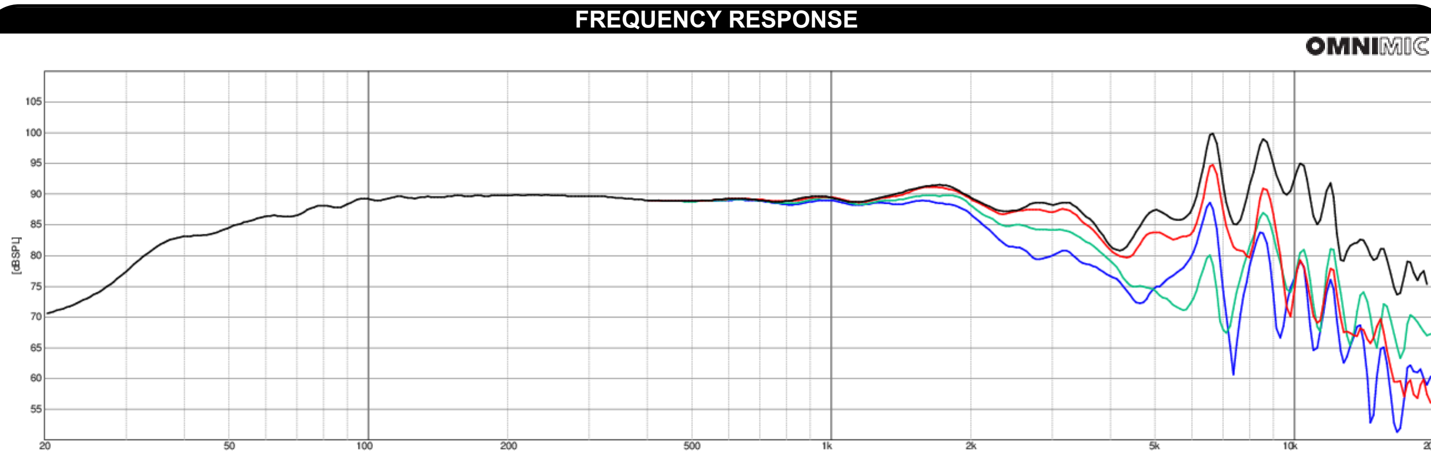
IMPEDANCE/PHASE



FEATURES

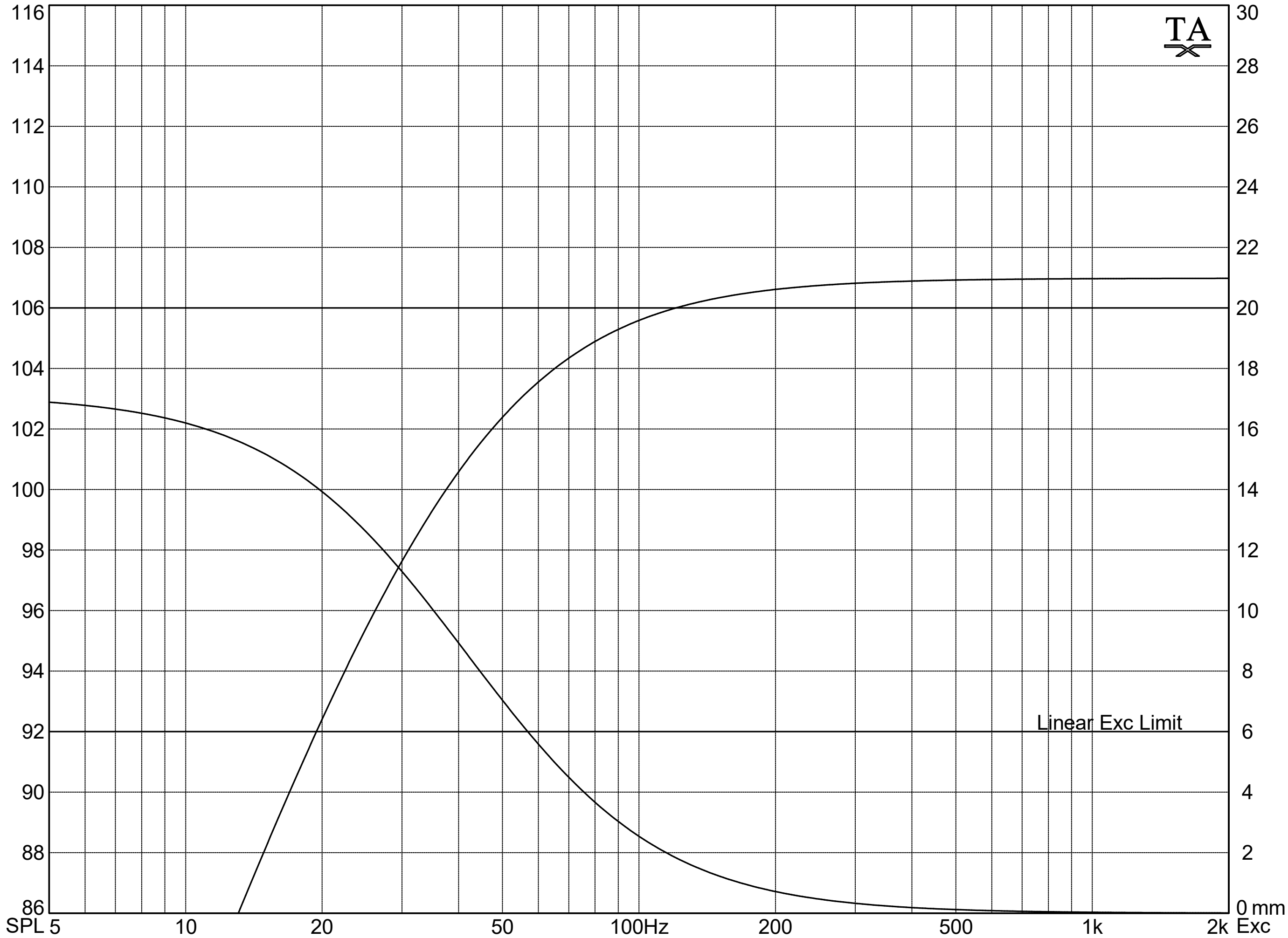
- Great replacement for the Dayton RS180S-8 7" Reference Shielded Woofer 8 Ohm
- 4 ohm impedance is perfect for series pairs in MTMs and center channel speakers
- Excellent car audio midrange/midbass
- High-end low-distortion motor with two shorting paths to reduce inductance

FREQUENCY RESPONSE



Note: 1/24th octave smoothing - nearfield response included in graph below 450 Hz.

Black = 0°
Red = 15°
Green = 30°
Blue = 45°



Driver Parameters

Driver: Dayton Audio RS180-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	89.2	dB SPL
Free Air Resonance	f(s) =	38.4	Hz
Total Q	Q(ts) =	0.46	
Electrical Q	Q(es) =	0.59	
Mechanical Q	Q(ms) =	2.13	
Equivalent Volume	V(as) =	0.7487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	4.125	cu ft
Closed Box Q	Q(tc) =	0.5	
System Resonance	F(sc) =	41.74	Hz
Compliance Ratio	alpha =	0.1815	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	60	Watts
SPL Distance	D =	1	m

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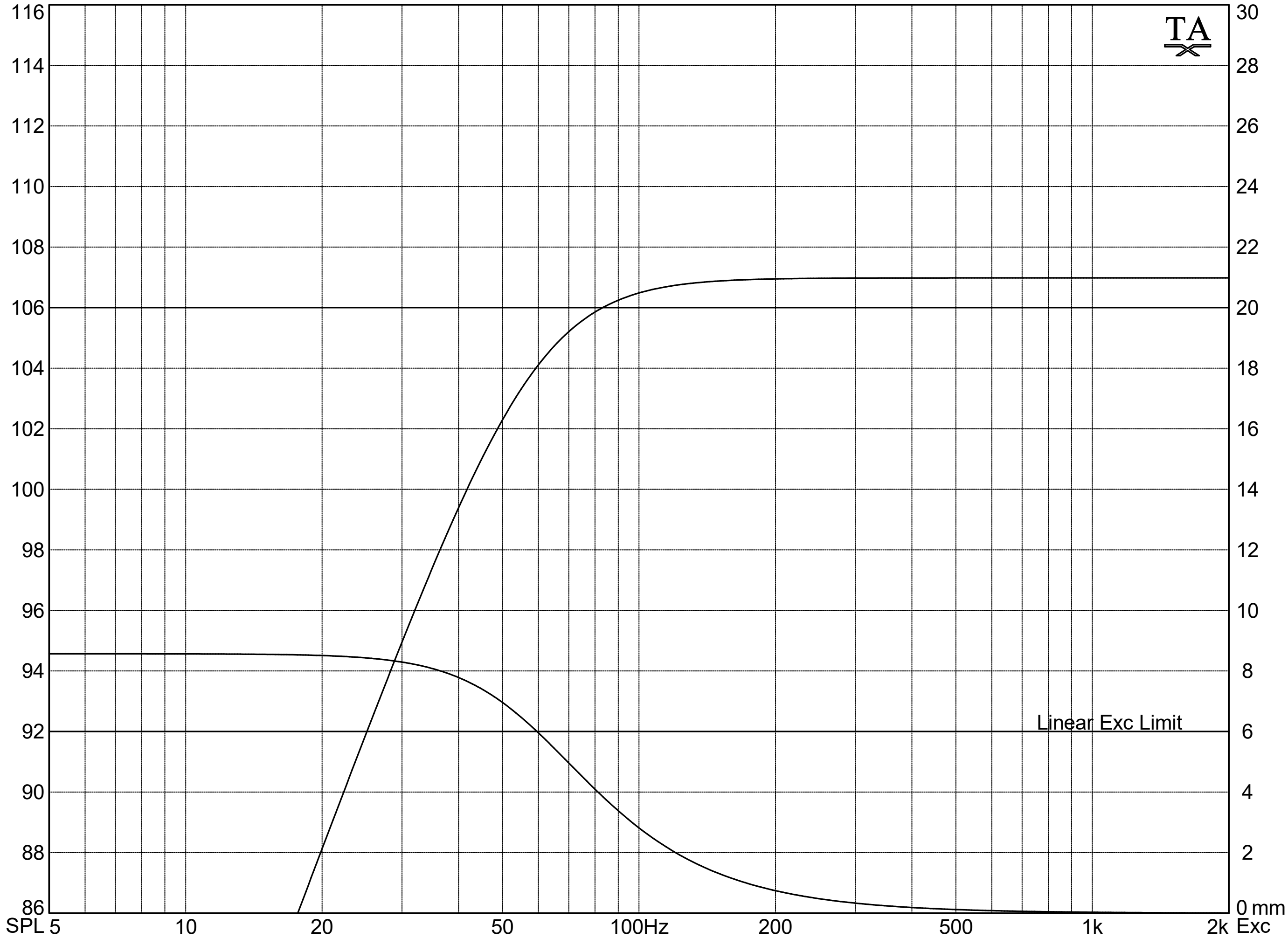
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date:

Rev:



Driver Parameters

Driver: **Dayton Audio RS180-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	89.2	dB SPL
Free Air Resonance	f(s) =	38.4	Hz
Total Q	Q(ts) =	0.46	
Electrical Q	Q(es) =	0.59	
Mechanical Q	Q(ms) =	2.13	
Equivalent Volume	V(as) =	0.7487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	0.5496	cu ft
Closed Box Q	Q(tc) =	0.707	
System Resonance	F(sc) =	59.02	Hz
Compliance Ratio	alpha =	1.362	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	60	Watts
SPL Distance	D =	1	m

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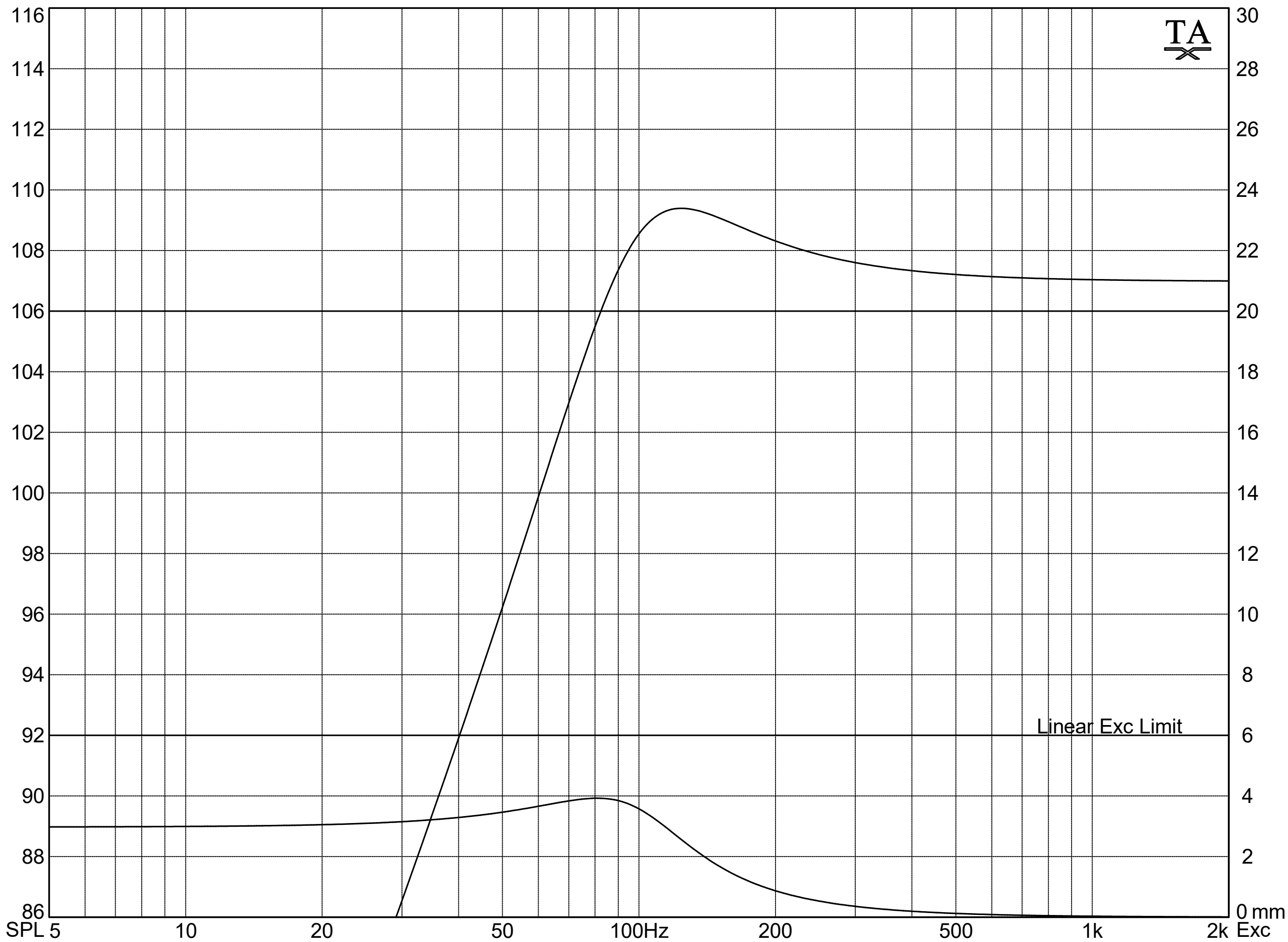
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS180-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	89.2	dB SPL
Free Air Resonance	f(s) =	38.4	Hz
Total Q	Q(ts) =	0.46	
Electrical Q	Q(es) =	0.59	
Mechanical Q	Q(ms) =	2.13	
Equivalent Volume	V(as) =	0.7487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	0.129	cu ft
Closed Box Q	Q(tc) =	1.2	
System Resonance	F(sc) =	100.2	Hz
Compliance Ratio	alpha =	5.805	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	60	Watts
SPL Distance	D =	1	m

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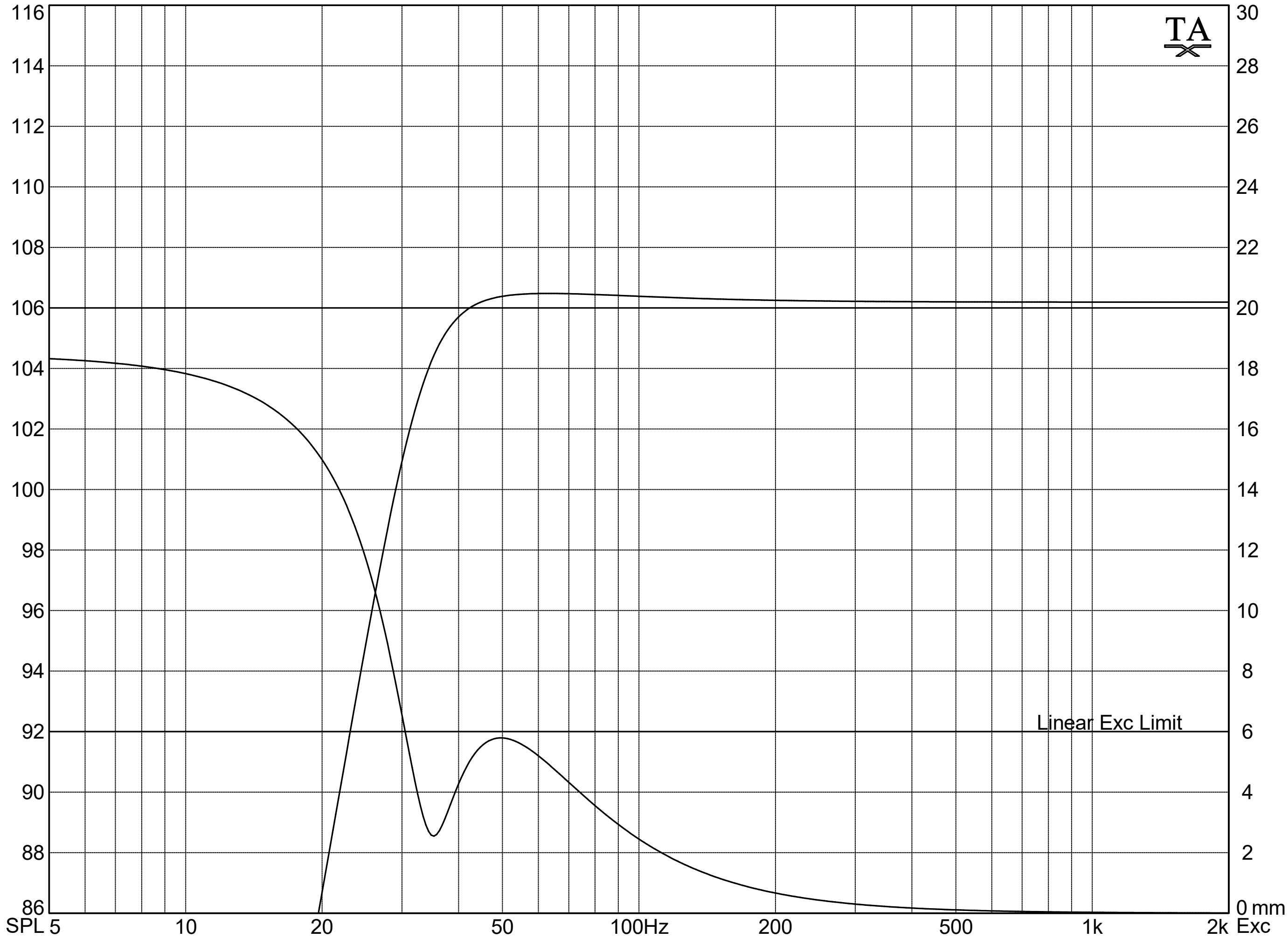
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS180-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	89.2	dB SPL
Free Air Resonance	f(s) =	38.4	Hz
Total Q	Q(ts) =	0.46	
Electrical Q	Q(es) =	0.59	
Mechanical Q	Q(ms) =	2.13	
Equivalent Volume	V(as) =	0.7487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	1	cu ft
Closed Box Q	Q(tc) =	0.6083	
Box Frequency	F(B) =	35	Hz
Min Rec Vent Area	S(vMin) =	3.25	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.7487	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	50	Watts
SPL Distance	D =	1	m

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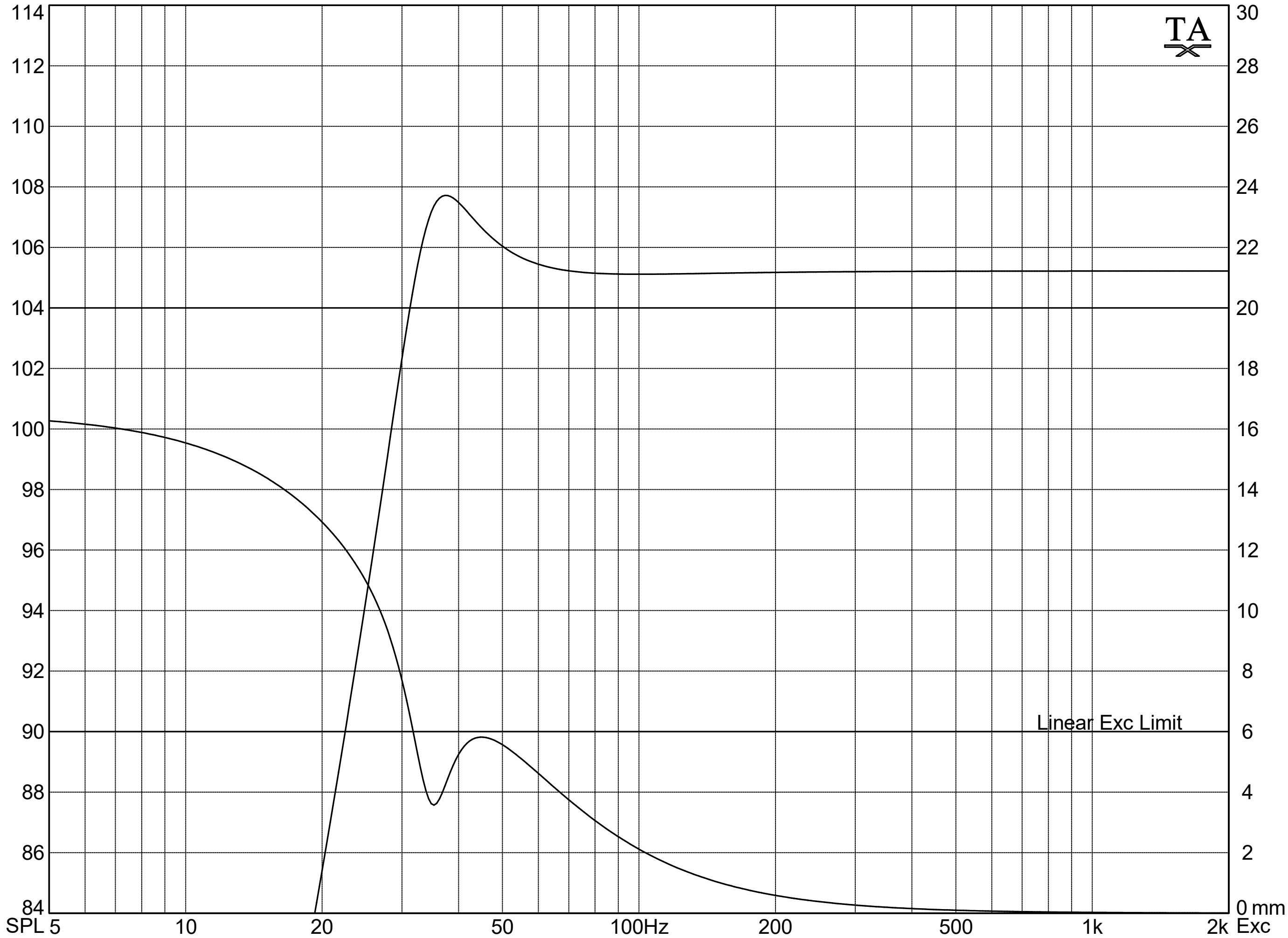
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS180-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	89.2	dB SPL
Free Air Resonance	f(s) =	38.4	Hz
Total Q	Q(ts) =	0.46	
Electrical Q	Q(es) =	0.59	
Mechanical Q	Q(ms) =	2.13	
Equivalent Volume	V(as) =	0.7487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	2	cu ft
Closed Box Q	Q(tc) =	0.5393	
Box Frequency	F(B) =	35	Hz
Min Rec Vent Area	S(vMin) =	3.25	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.3743	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	40	Watts
SPL Distance	D =	1	m

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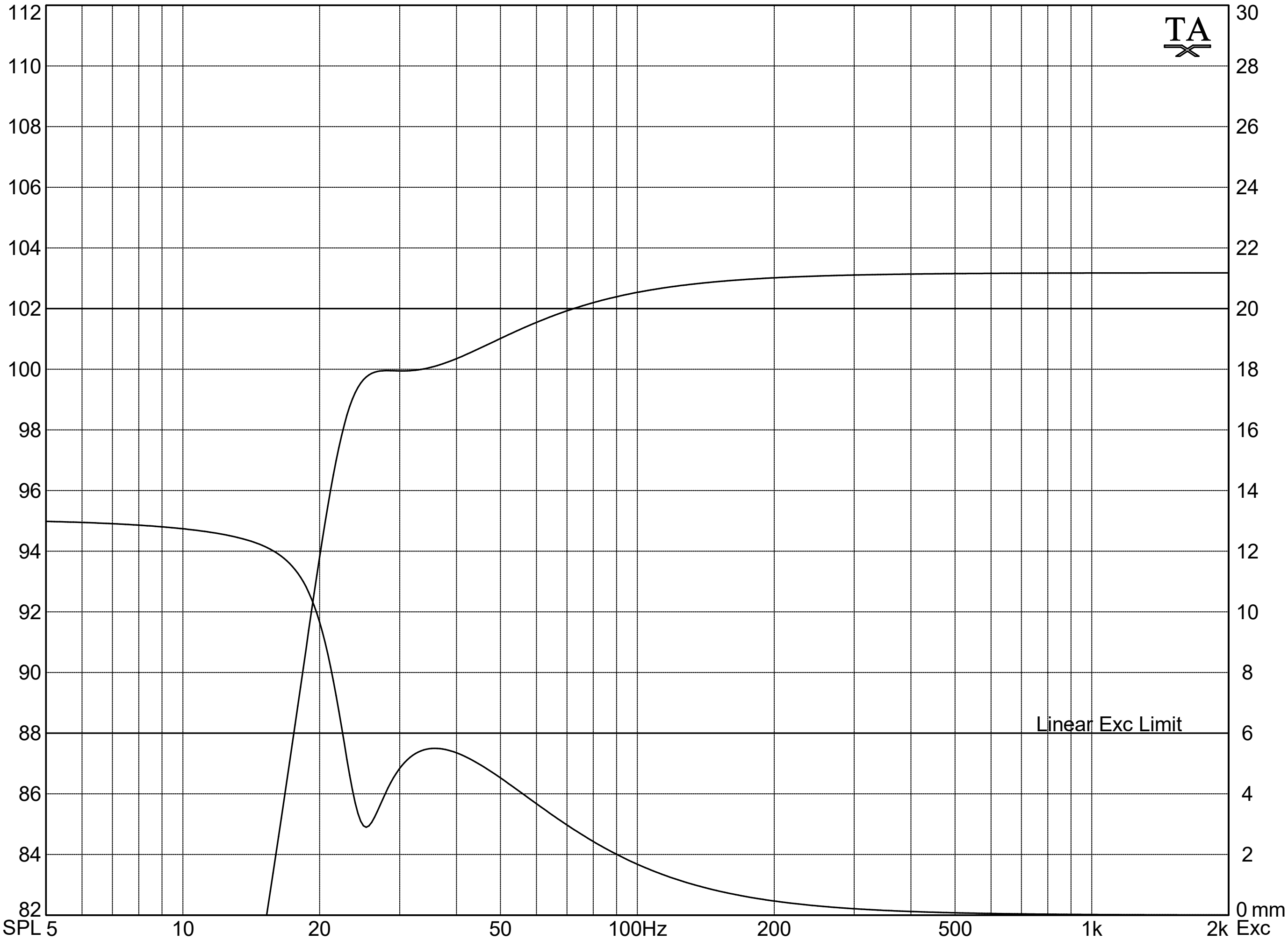
System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS180-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	89.2	dB SPL
Free Air Resonance	f(s) =	38.4	Hz
Total Q	Q(ts) =	0.46	
Electrical Q	Q(es) =	0.59	
Mechanical Q	Q(ms) =	2.13	
Equivalent Volume	V(as) =	0.7487	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	0	Watts
Max Linear Excursion	X(max) =	6	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	1.75	cu ft
Closed Box Q	Q(tc) =	0.5497	
Box Frequency	F(B) =	25	Hz
Min Rec Vent Area	S(vMin) =	2.32	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.4278	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	25	Watts
SPL Distance	D =	1	m

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System Name:

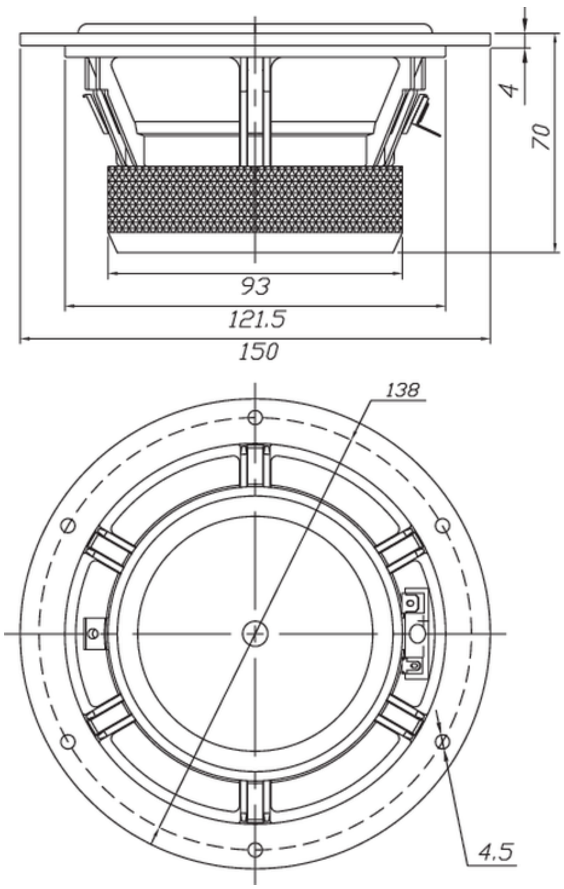
4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:

RS150-4 6" Reference Woofer 4 Ohm

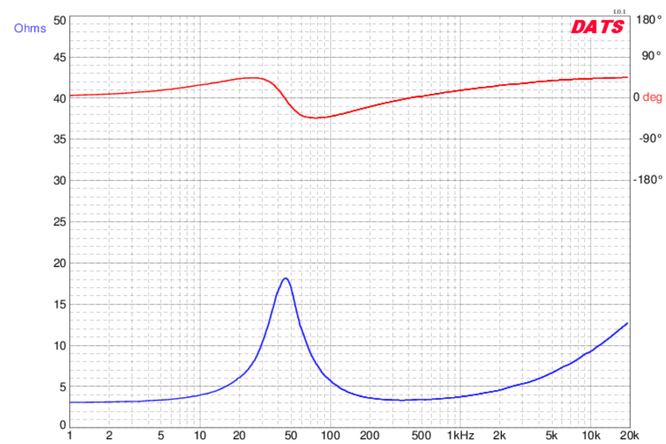
RS150-4



PARAMETERS

Impedance	4 ohms
Re	3.1 ohms
Le	0.34 mH @ 1 kHz
Fs	45.1 Hz
Qms	1.96
Qes	0.40
Qts	0.33
Mms	7.7g
Cms	1.62 mm/N
Sd	85 cm²
Vd	37.4 cm³
BL	4.1 Tm
Vas	16.4 liters
Xmax	4.4 mm
VC Diameter	25 mm
SPL	91.8 dB @ 2.83V/1m
RMS Power Handling	40 watts
Usable Frequency Range (Hz)	48 - 4,000 Hz

IMPEDANCE/PHASE

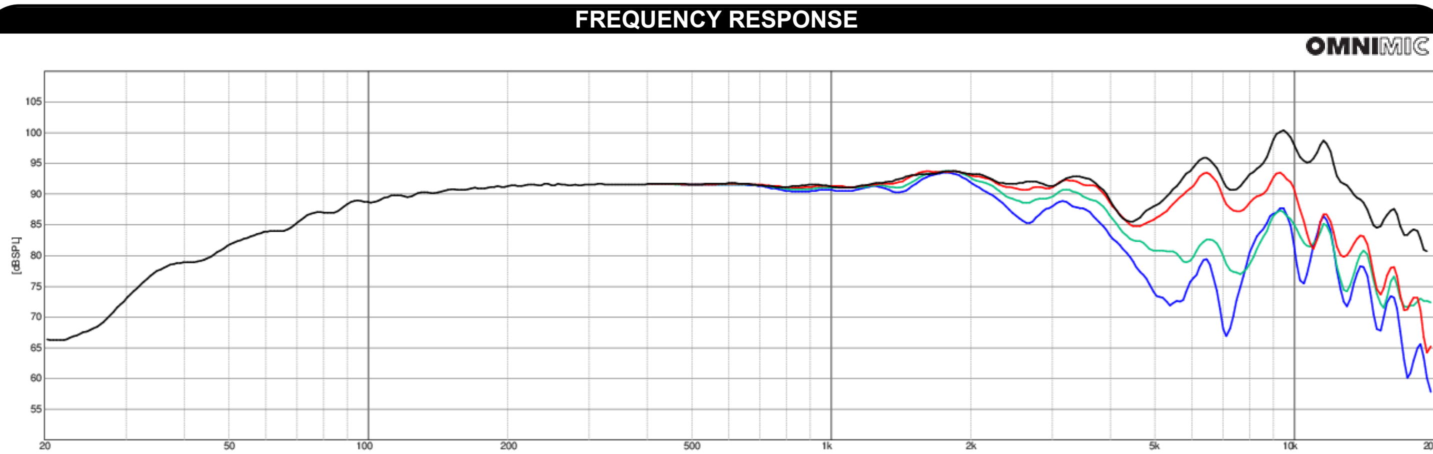


FEATURES

- Great replacement for the Dayton RS150S-8 6" Reference Shielded Woofer 8 Ohm
- 4 ohm impedance is perfect for series pairs in MTMs and center channel speakers
- Excellent car audio midrange/midbass
- High-end low-distortion motor with two shorting paths to reduce inductance

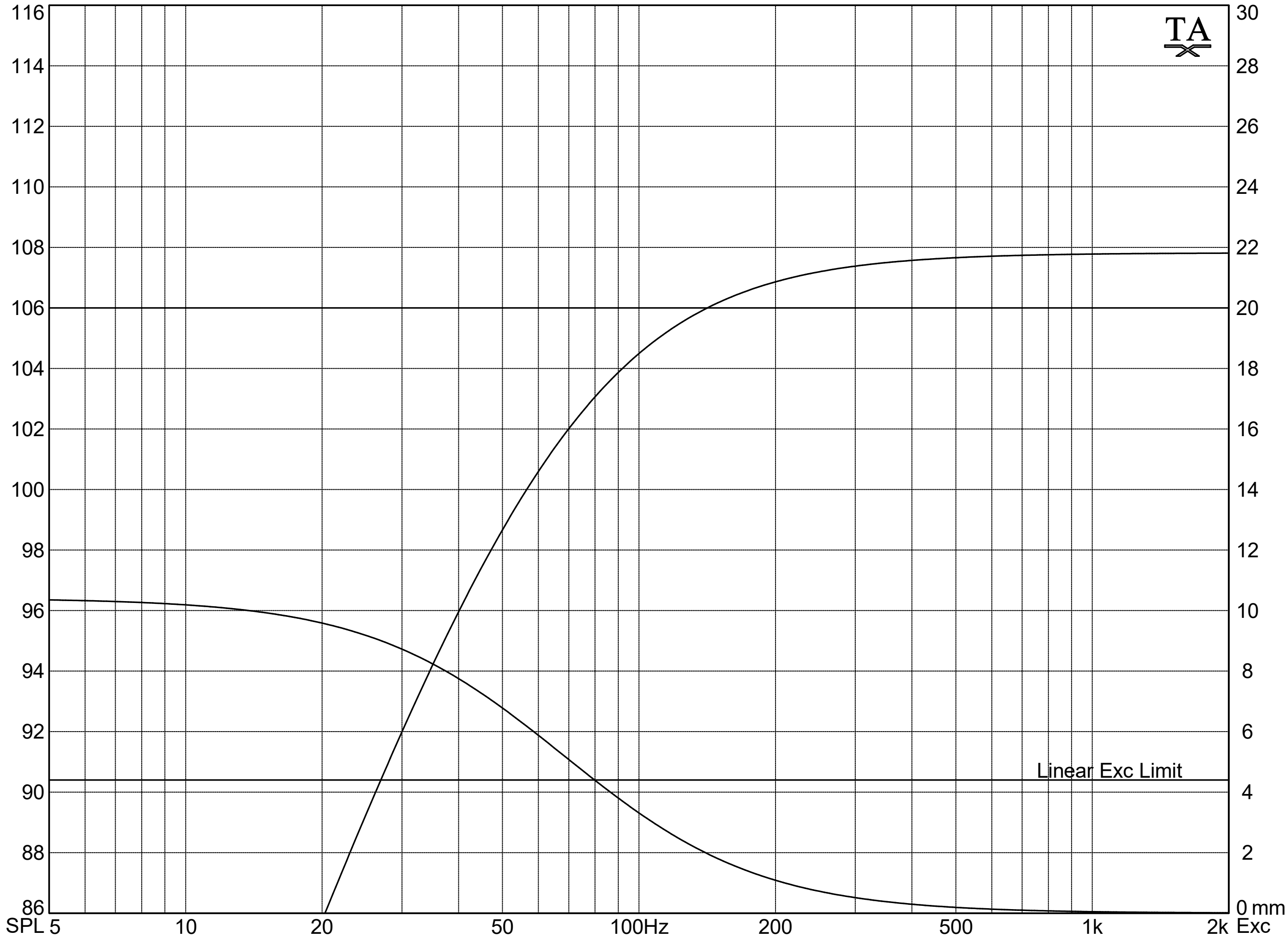
FREQUENCY RESPONSE

OMNIMIC



Note: 1/24th octave smoothing - nearfield response included in graph below 450 Hz.

Black = 0°
Red = 15°
Green = 30°
Blue = 45°



Driver Parameters

Driver: Dayton Audio RS150-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.8	dB SPL
Free Air Resonance	f(s) =	45.1	Hz
Total Q	Q(ts) =	0.33	
Electrical Q	Q(es) =	0.4	
Mechanical Q	Q(ms) =	1.96	
Equivalent Volume	V(as) =	0.5792	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	40	Watts
Max Linear Excursion	X(max) =	4.4	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 2nd Order Closed Box

Box Volume	V(B) =	0.447	cu ft
Closed Box Q	Q(tc) =	0.5	
System Resonance	F(sc) =	68.33	Hz
Compliance Ratio	alpha =	1.295	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	40	Watts
SPL Distance	D =	1	m

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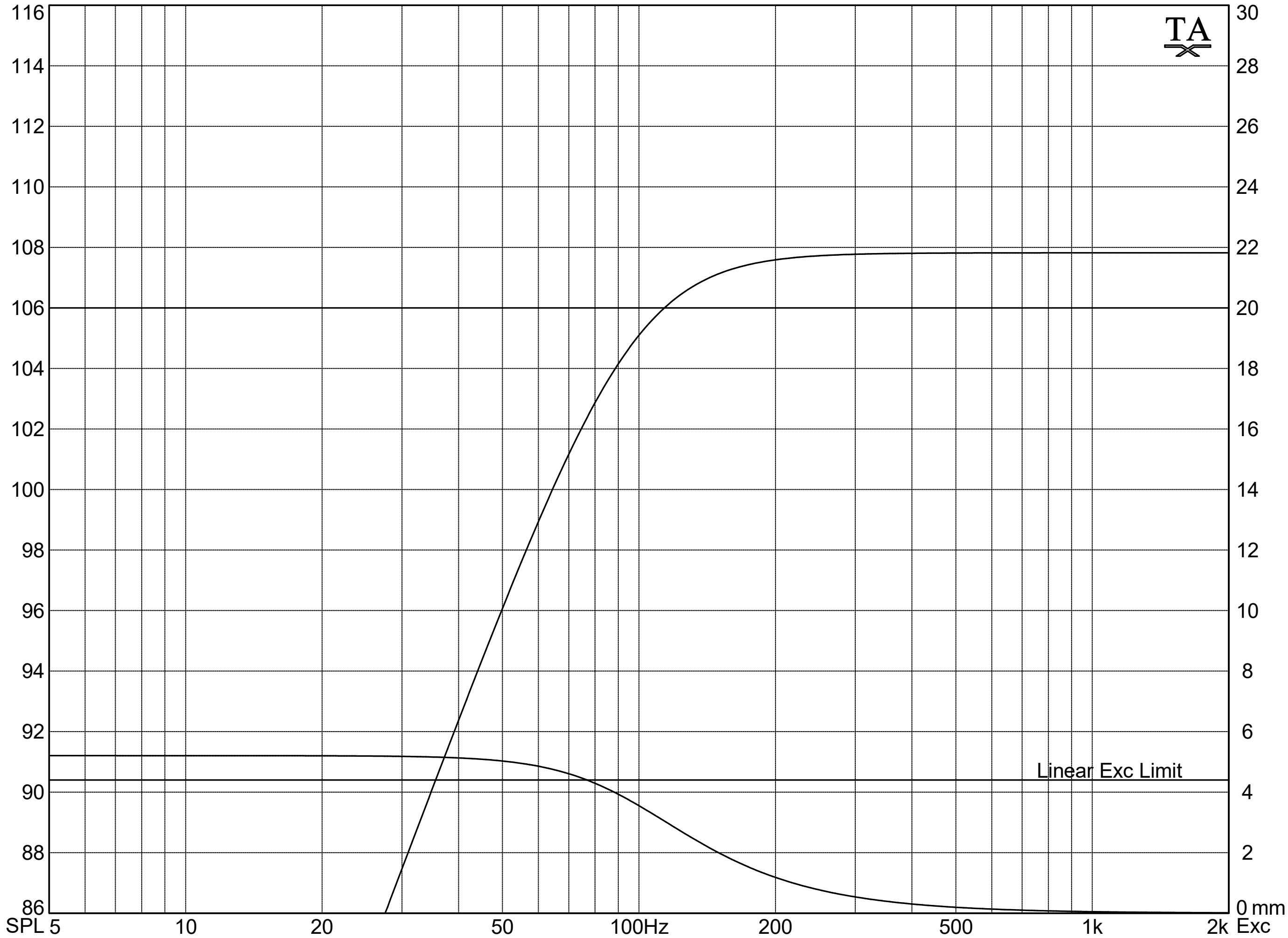
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS150-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.8	dB SPL
Free Air Resonance	f(s) =	45.1	Hz
Total Q	Q(ts) =	0.33	
Electrical Q	Q(es) =	0.4	
Mechanical Q	Q(ms) =	1.96	
Equivalent Volume	V(as) =	0.5792	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	40	Watts
Max Linear Excursion	X(max) =	4.4	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	0.1613	cu ft
Closed Box Q	Q(tc) =	0.707	
System Resonance	F(sc) =	96.63	Hz
Compliance Ratio	alpha =	3.59	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	40	Watts
SPL Distance	D =	1	m

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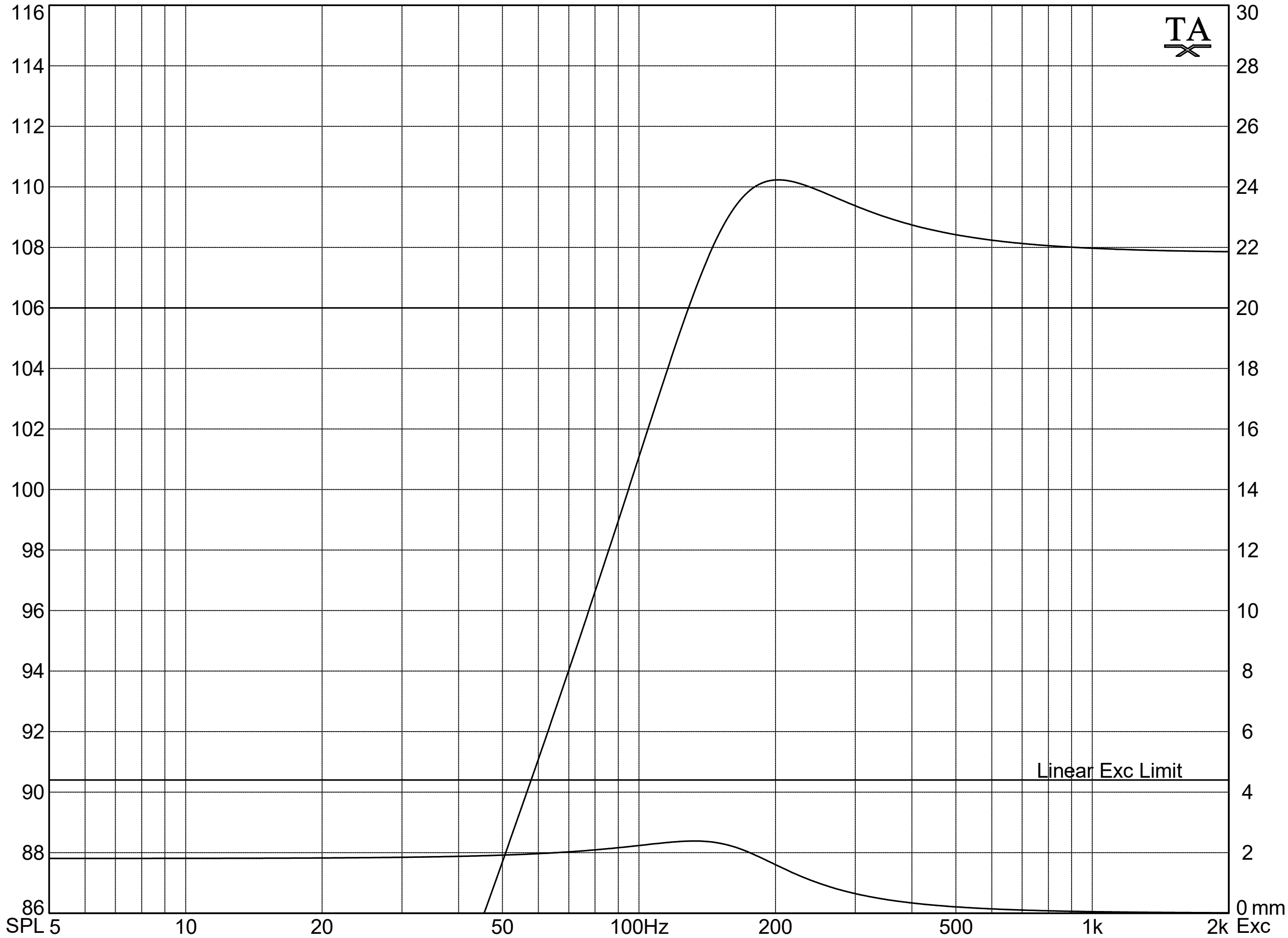
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS150-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.8	dB SPL
Free Air Resonance	f(s) =	45.1	Hz
Total Q	Q(ts) =	0.33	
Electrical Q	Q(es) =	0.4	
Mechanical Q	Q(ms) =	1.96	
Equivalent Volume	V(as) =	0.5792	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	40	Watts
Max Linear Excursion	X(max) =	4.4	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **2nd Order Closed Box**

Box Volume	V(B) =	0.04738	cu ft
Closed Box Q	Q(tc) =	1.2	
System Resonance	F(sc) =	164	Hz
Compliance Ratio	alpha =	12.22	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	40	Watts
SPL Distance	D =	1	m

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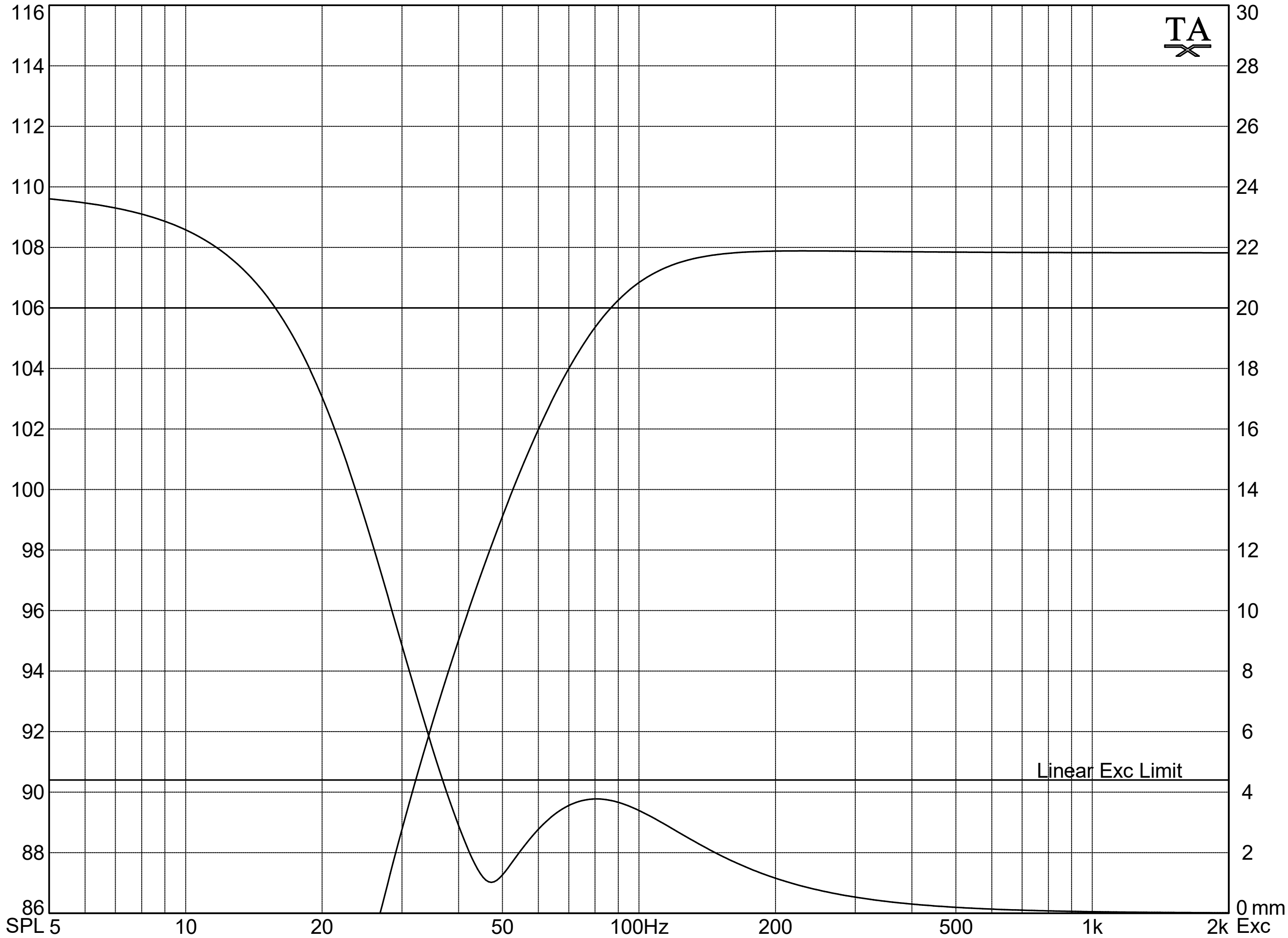
System Name:

2nd Order Closed Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: Dayton Audio RS150-4

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.8	dB SPL
Free Air Resonance	f(s) =	45.1	Hz
Total Q	Q(ts) =	0.33	
Electrical Q	Q(es) =	0.4	
Mechanical Q	Q(ms) =	1.96	
Equivalent Volume	V(as) =	0.5792	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	40	Watts
Max Linear Excursion	X(max) =	4.4	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	0.2	cu ft
Closed Box Q	Q(tc) =	0.6513	
Box Frequency	F(B) =	47	Hz
Min Rec Vent Area	S(vMin) =	2.18	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	2.896	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	40	Watts
SPL Distance	D =	1	m

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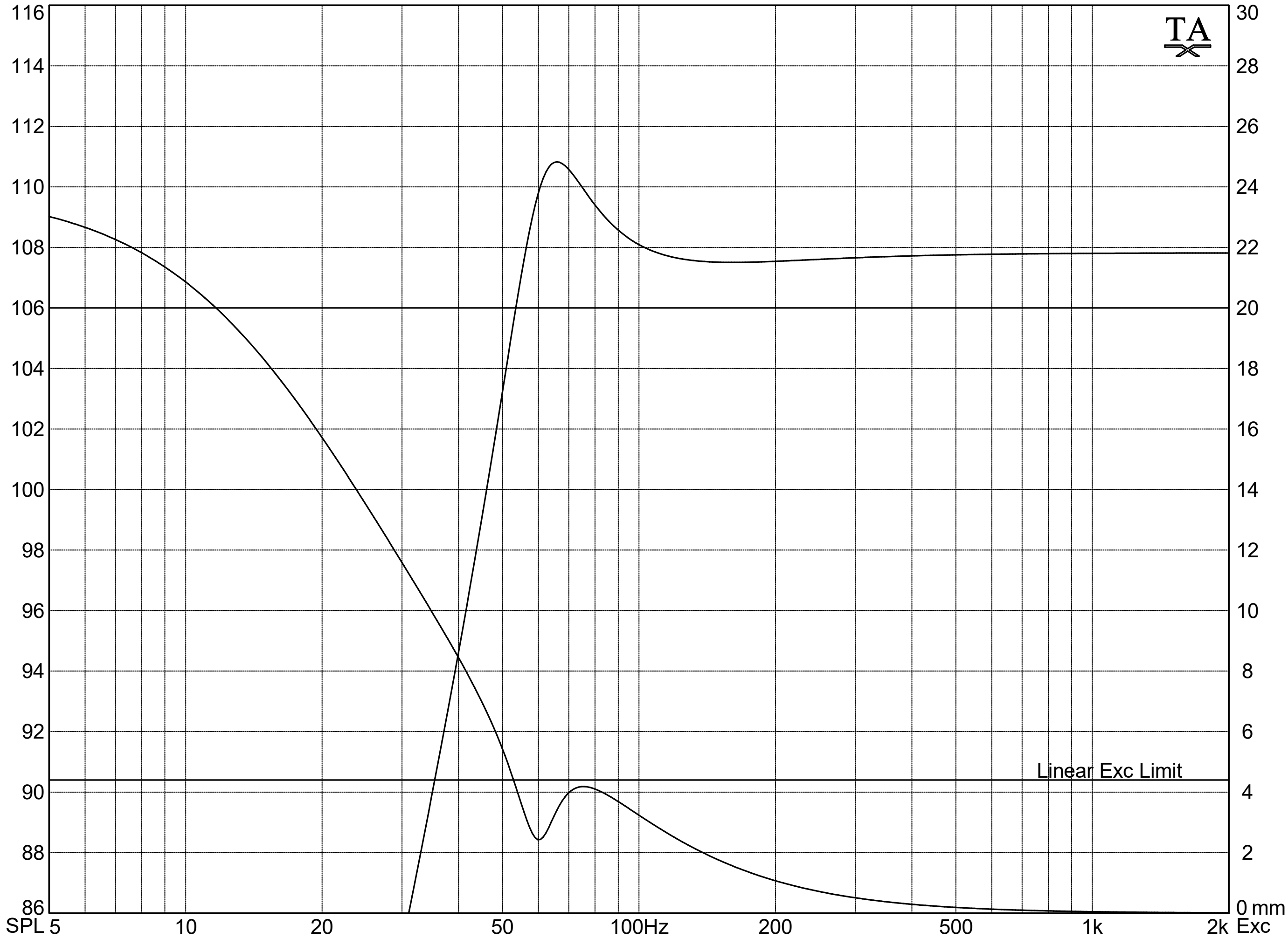
My Phone

System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:



Driver Parameters

Driver: **Dayton Audio RS150-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.8	dB SPL
Free Air Resonance	f(s) =	45.1	Hz
Total Q	Q(ts) =	0.33	
Electrical Q	Q(es) =	0.4	
Mechanical Q	Q(ms) =	1.96	
Equivalent Volume	V(as) =	0.5792	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	40	Watts
Max Linear Excursion	X(max) =	4.4	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	0.7	cu ft
Closed Box Q	Q(tc) =	0.4461	
Box Frequency	F(B) =	60	Hz
Min Rec Vent Area	S(vMin) =	2.78	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	0.8274	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	40	Watts
SPL Distance	D =	1	m

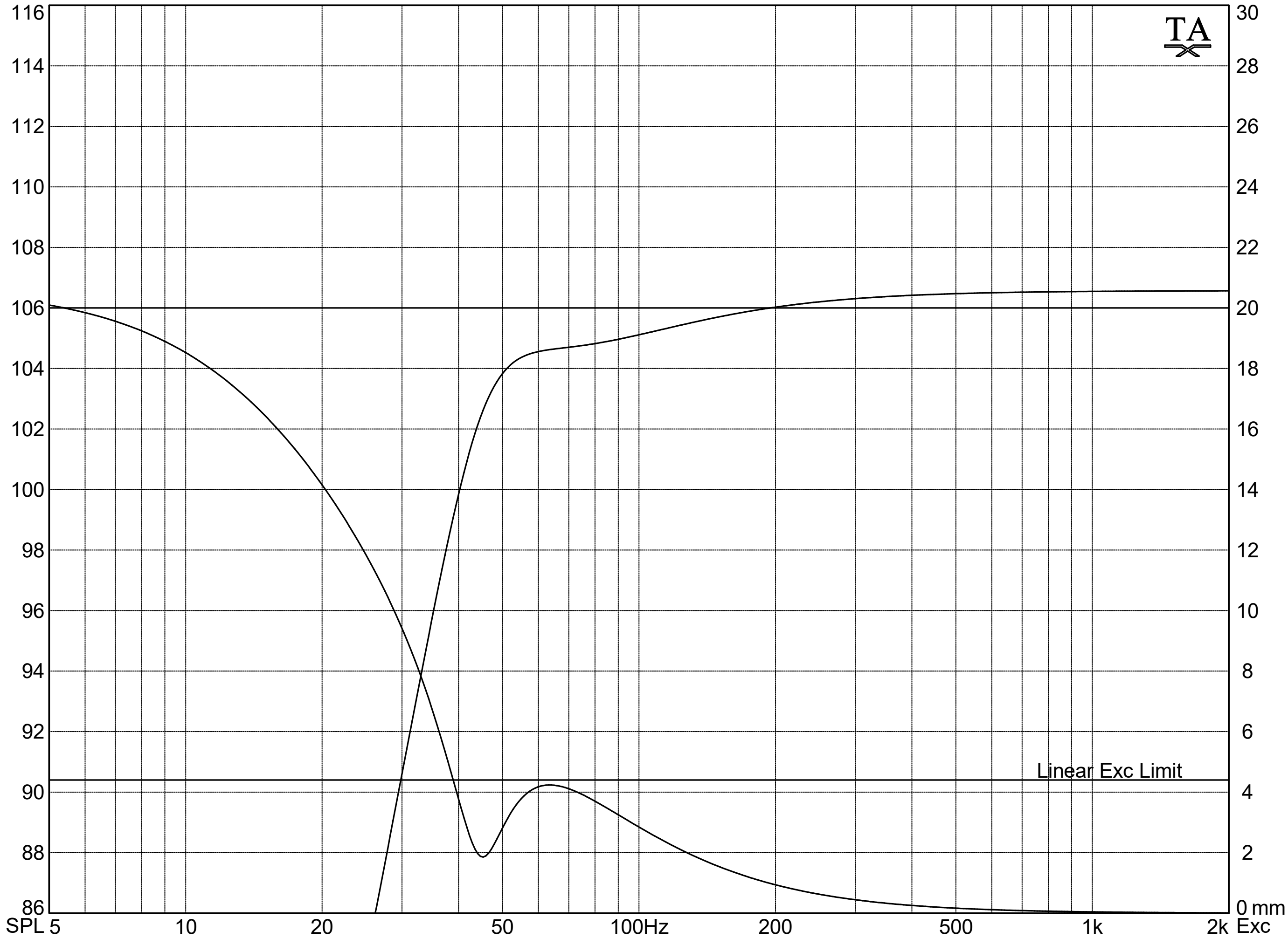
Michigan Technological University
My Address, line 1
My Address, line 2
My Country My Phone

System Name:

4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date: Rev:



Driver Parameters

Driver: **Dayton Audio RS150-4**

Nominal Diameter	D =	0	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	91.8	dB SPL
Free Air Resonance	f(s) =	45.1	Hz
Total Q	Q(ts) =	0.33	
Electrical Q	Q(es) =	0.4	
Mechanical Q	Q(ms) =	1.96	
Equivalent Volume	V(as) =	0.5792	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	0	Ohms
Max Thermal Power	P(t) =	40	Watts
Max Linear Excursion	X(max) =	4.4	mm
Max Excursion	X(lim) =	0	mm
Voice Coil Diam.	D(vc) =	0	mm

Driver Notes:

NOTE: Reference Efficiency was calculated based on the 1W/1m sensitivity.

System Notes:

Box Parameters

System Type: **4th Order Vented Box**

Box Volume	V(B) =	0.5	cu ft
Closed Box Q	Q(tc) =	0.4848	
Box Frequency	F(B) =	45	Hz
Min Rec Vent Area	S(vMin) =	2.09	sq in
Vent Surface Area	S(v) =	0	sq in
Vent Length	L(v) =	0	in
Compliance Ratio	alpha =	1.158	
Box Loss Q	Q(B) =	7	

System Parameters

No. of Drivers	N =	1	
Isobaric Factor	I =	1	(1=normal, 2=iso)
Input Power	P(in) =	30	Watts
SPL Distance	D =	1	m

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My Country
My Phone

System Name:

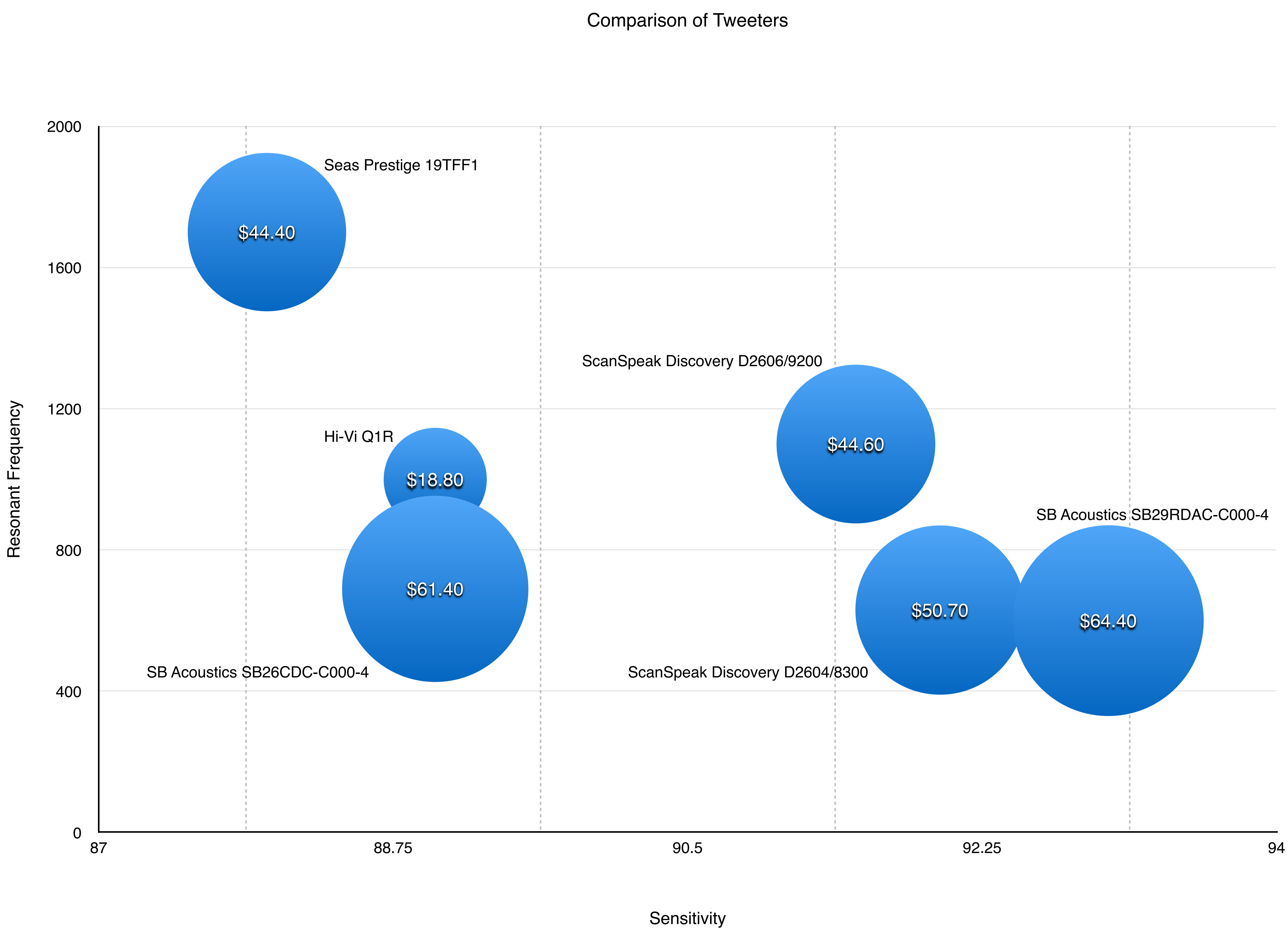
4th Order Vented Box

Designer: Ace Hobbs
Title: Student

Rev Date:
Rev:

Tweeters

	Nominal Size	Cone	Price	Resonant Freq (Hz)	Sensitivity	Long Term Power	Short Term Power	Thermal SPL Limit	Mechanical SPL Limit
Hi-Vi Q1R	1”	Fabric	$18.80	1000	89	15		100.8	
Seas Prestige 19TFF1	0.75”	Soft	$44.40	1700	88	90	220	107.5	111.4
ScanSpeak Discovery D2606/9200	1”	Soft	$44.60	1100	91.5	100	200	111.5	114.5
ScanSpeak Discovery D2604/8300	1”	Soft	$50.70	630	92	100	240	112.0	115.8
SB Acoustics SB26CDC-C000-4	1”	Ceramic	$61.40	690	89	100		109.0	
SB Acoustics SB29RDAC-C000-4	1”	Soft	$64.40	600	93	100		113.0	
Comparison Loudspeakers									
Polk Audio MXT70	1”	Terylene	$558.00		89	200		112.0	
Totem Wind	1”	Aluminum	$12000.00		87	250		111.0	
Revel F206	1”	Aluminum	$1000.00		88	200		111.0	
Totem Signature One	1”	Aluminum	$3500.00		87.5	200		110.5	
Polk Audio Reserve R100	1”	Paper	$649.00		86	150		107.8	
Revel M106	1”	Aluminum	$1100.00		87	150		108.8	


Comparison of Tweeters
Seas Prestige 19TFF1
$44.40
ScanSpeak Discovery D2606/9200
$44.60
Hi-Vi Q1R
$18.80
$61.40
SB Acoustics SB29RDAC-C000-4
$50.70
$64.40
SB Acoustics SB26CDC-C000-4
ScanSpeak Discovery D2604/8300
Resonant Frequency
2000
1600
1200
800
400
0
87
88.75
90.5
92.25
94
Sensitivity

My best mid/high sensitivity would be 91 dB @ 1W/1m. This is a pretty lofty goal given my designs, and I don't necessarily expect to reach it. My great outcome level would be 88 dB, and my good outcome level would be 85 dB.

5.0 Tweeters

5.? Scan-Speak Discovery D2606/9200

The Scan-Speak Discovery D2606/9200 is a very desirable tweeter for my speaker design. The Discovery family tweeters feature fabric diaphragms with either traditional domes or ring radiators. In this instance, we have the classic dome design.

The sensitivity of the tweeter clocks in at 91.5 dB, which will pair nicely with the selection of woofers I am considering.

The off-axis response leaves a lot to be desired. At 10K Hz, the 60 degree off-axis response is over 20 dB down from the on-axis response. While I am not designing these speakers solely for great coverage, this is disappointing.

The on-axis frequency response makes a great case for this tweeter given the off-axis response. With a variance of +/- 1.5 dB across the usable frequency range, this tweeter will pair nicely with any woofer I can match it with. The natural second order roll-off will make the crossover design simpler, allowing for less components and overall, less power loss.

The impedance response seems to be relatively smooth, but it could be smoother. There are some small bumps along the road leading up to 10K Hz. This shouldn't be too big of an issue.

Aesthetically the tweeters are fine. They aren't very extravagant, but I am not looking to draw attention to the tweeters specifically. The classic design will fit in nicely with the rest of the design.

Figure 5 shows the frequency response graph provided by the company with some notes on it pointing out key technical specifications discussed above.

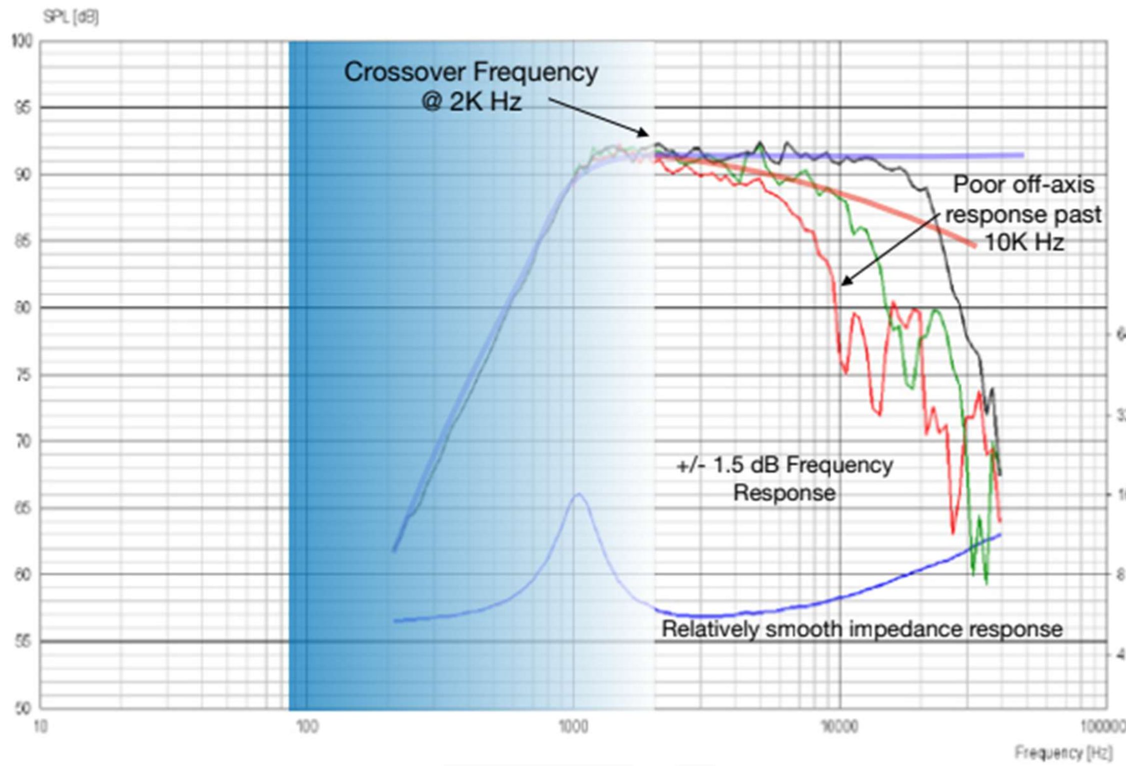


Figure 5 - Frequency response of the Scan-Speak Discovery D2606/9200 tweeter

5.? Scan-Speak Discovery D2604/8300

Another tweeter from the Discovery series piqued my interest based on the price point and slightly different technical characteristics.

The sensitivity is 92 dB, just a little louder than the model in section 5.?.

The off-axis response seems to be sub-par along this family of tweeters. At 10K Hz, the off-axis response is 20 dB down from the on-axis response.

The on-axis response is also a little scary. The variance of this tweeter is +/- 2 dB on-axis with a huge spike right before 20K Hz. While the frequency response looks desirable up until that point, some serious eq would need to be implemented to get that response under control. There is a natural first order roll off inherent to the tweeter which would help implement a second order crossover.

The impedance response seems to be a little smoother with no noticeable bumps after the resonant frequency.

Figure 6 shows the company provided frequency response graph with notes on the technical specifications discussed above.

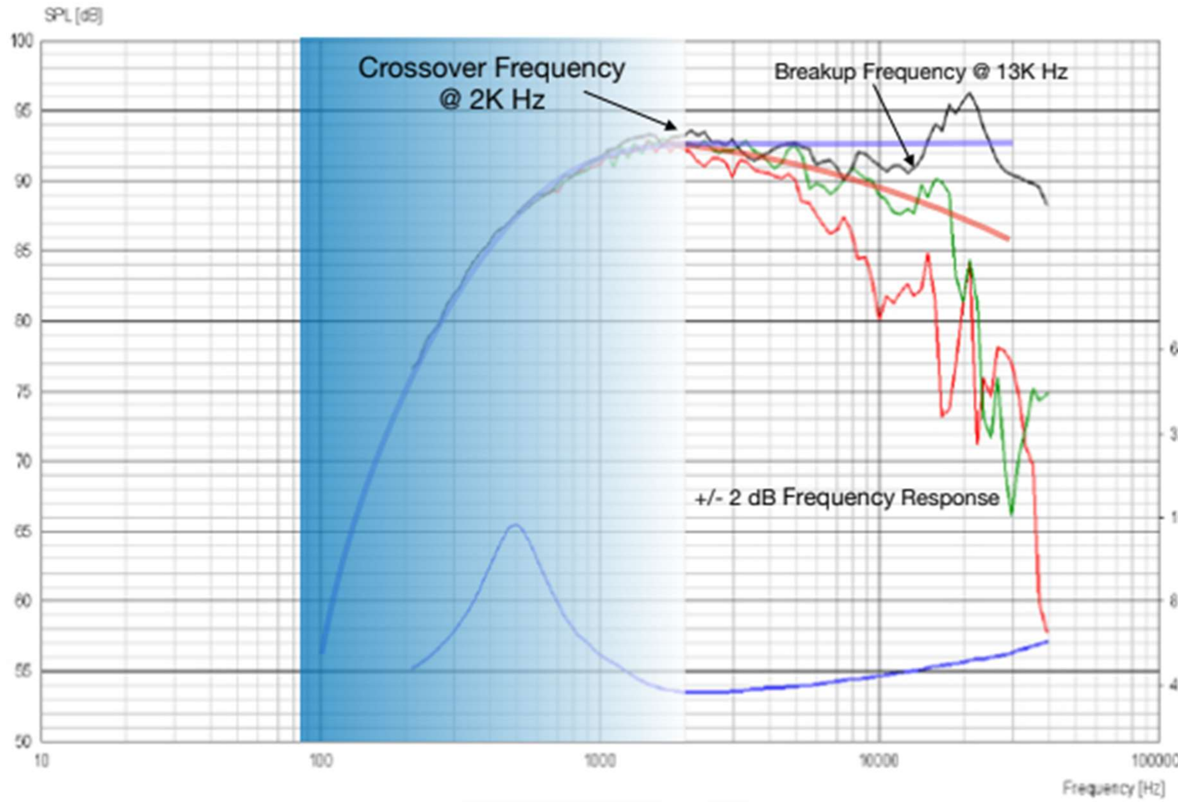


Figure 6 - Frequency response of the Scan-Speak Discovery D2604/8300

5.? Seas Prestige 19TFF1

The Seas Prestige series of tweeters is dedicated to "The Art of Sound Perfection" for an affordable cost[24].

The sensitivity of this tweeter is a tad low, clocking in at 88 dB. This would require careful attention when tuning the speaker as the woofer might overpower the tweeter.

The off-axis response is great on this tweeter. At 10K Hz, there is only a 6 dB difference at the farther off-axis angle provided on the frequency response graph (note that I could not find any indicators to the angles of off-axis shown in this graph).

The on-axis response is also stellar with a +/- 1 dB variance on the driver past 20K Hz. The resonant frequency is a little higher, but not too high for a crossover at 2500 Hz. The driver also has a natural first order roll off which would integrate nicely into a second order crossover.

The impedance response is very smooth along its path with no noticeable bumps.

[24] https://www.seas.no/index.php?option=com_content&view=category&id=43&Itemid=237

Figure 7 shows the company provided frequency response graph with added notes on important technical specifications.

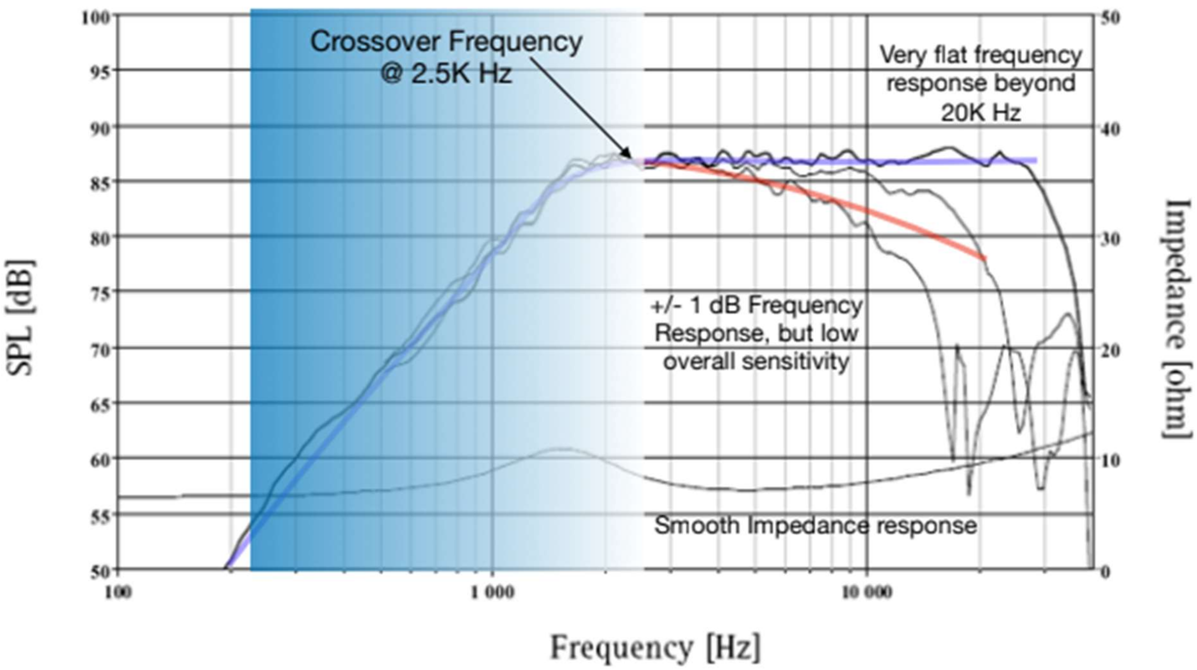


Figure 7 - Frequency response of the Seas Prestige 19TFF1 tweeter

Appendix B – Tuning Data

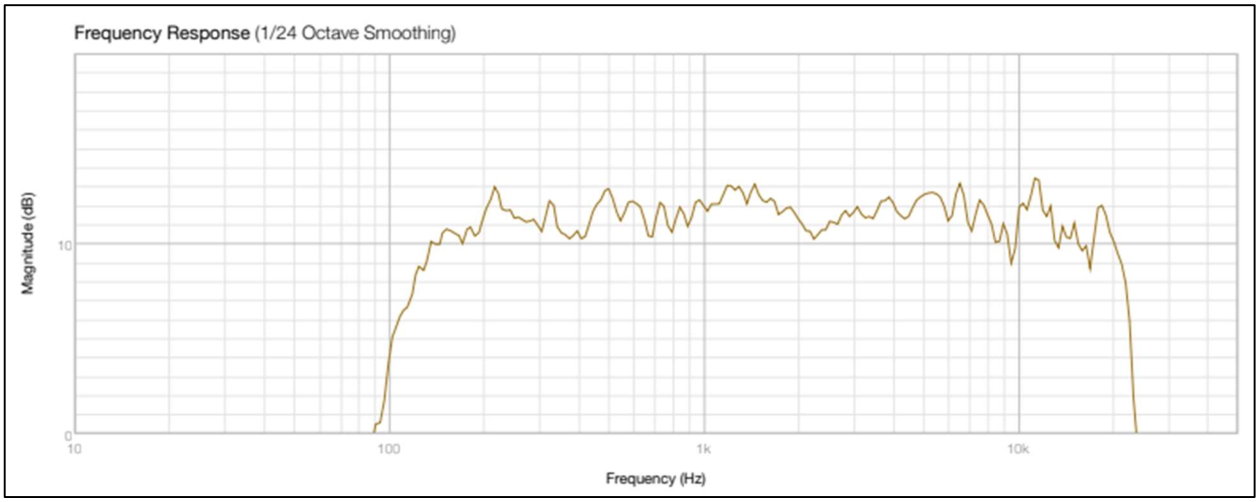


Figure 1 - frequency response of right mid/high, 20 dB amplitude

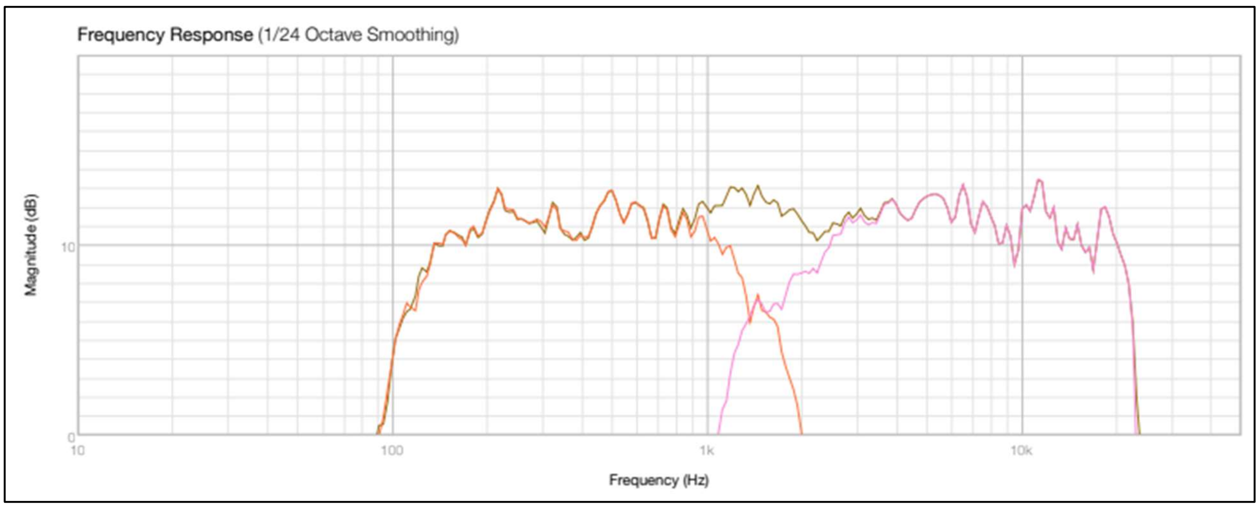


Figure 2 - integrated frequency response of rght mid/high

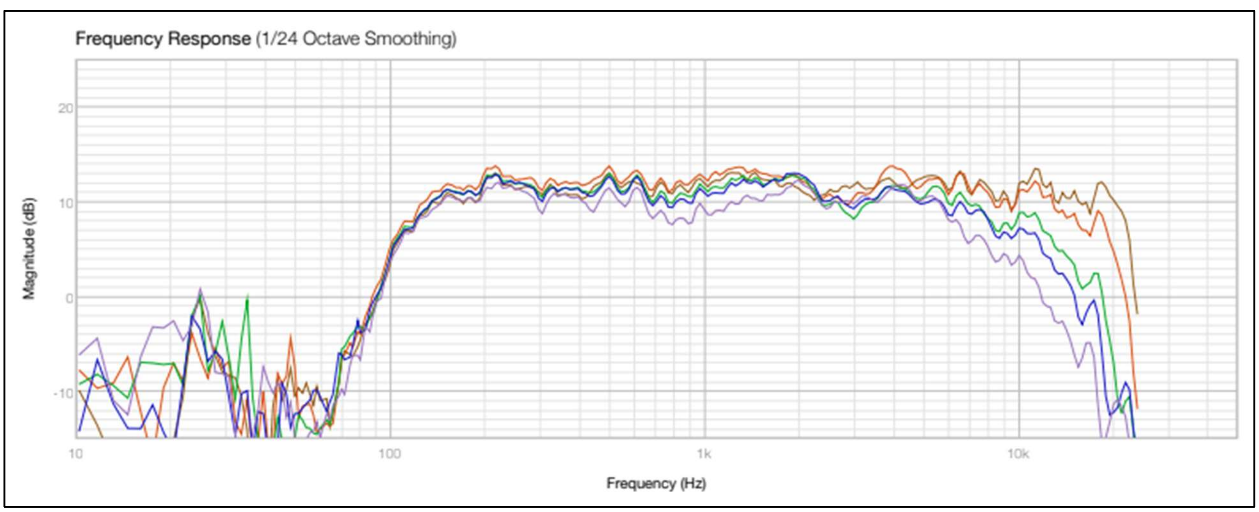


Figure 3 - horizontal off axis response of right mid/high, Brown – On Axis / Red – 15° / Green - 30° / Blue - 45° / Purple - 60°

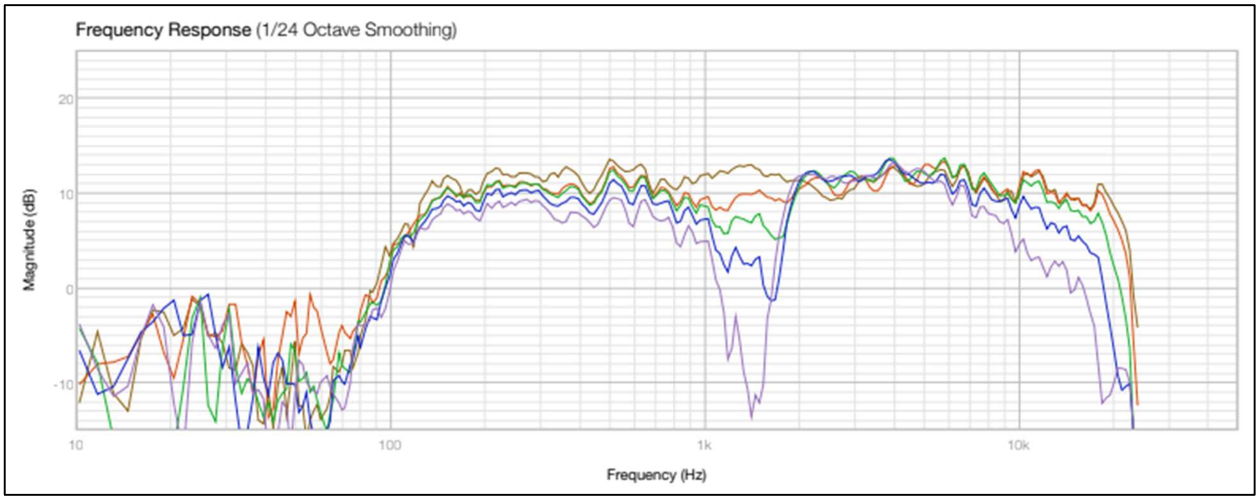


Figure 4 -vertical off axis response of right mid/high, Brown – On Axis / Red – 15° / Green - 30° / Blue - 45° / Purple - 60°

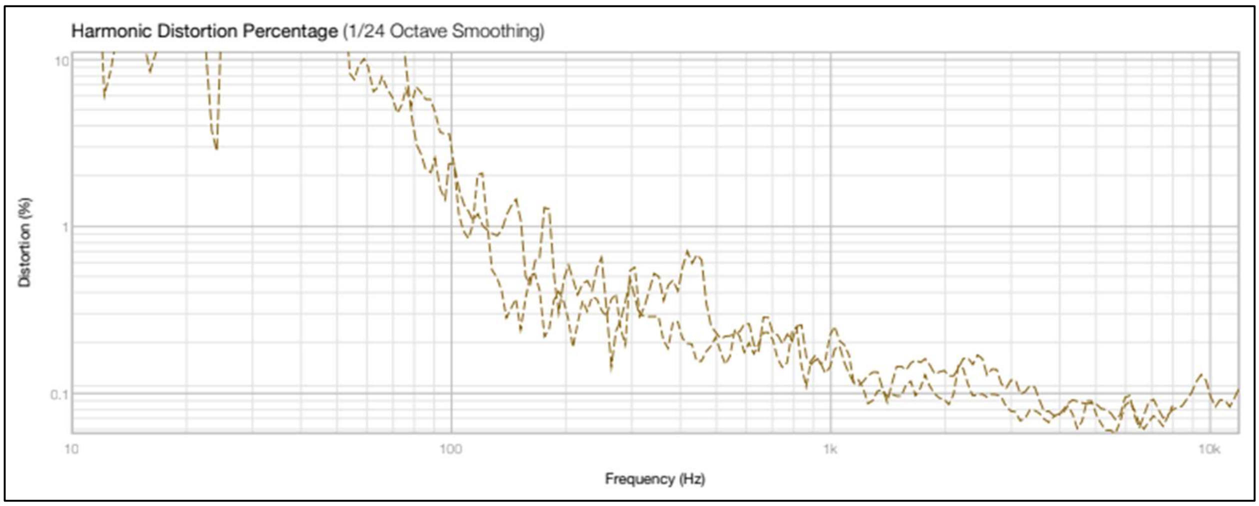


Figure 5 - harmonic distortion of right mid/high

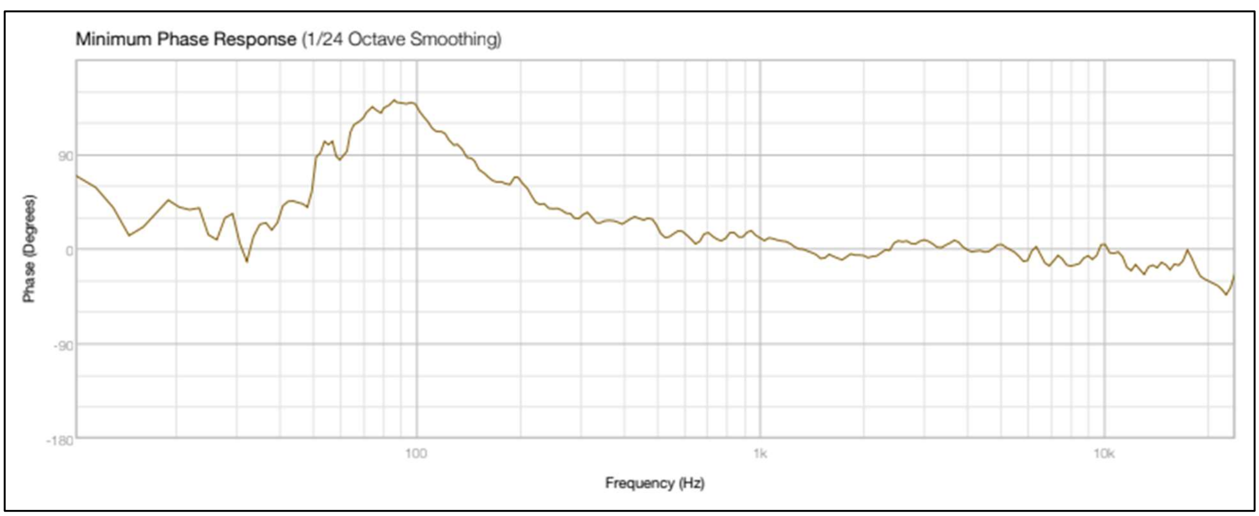


Figure 6 - minimum phase response of right mid/high

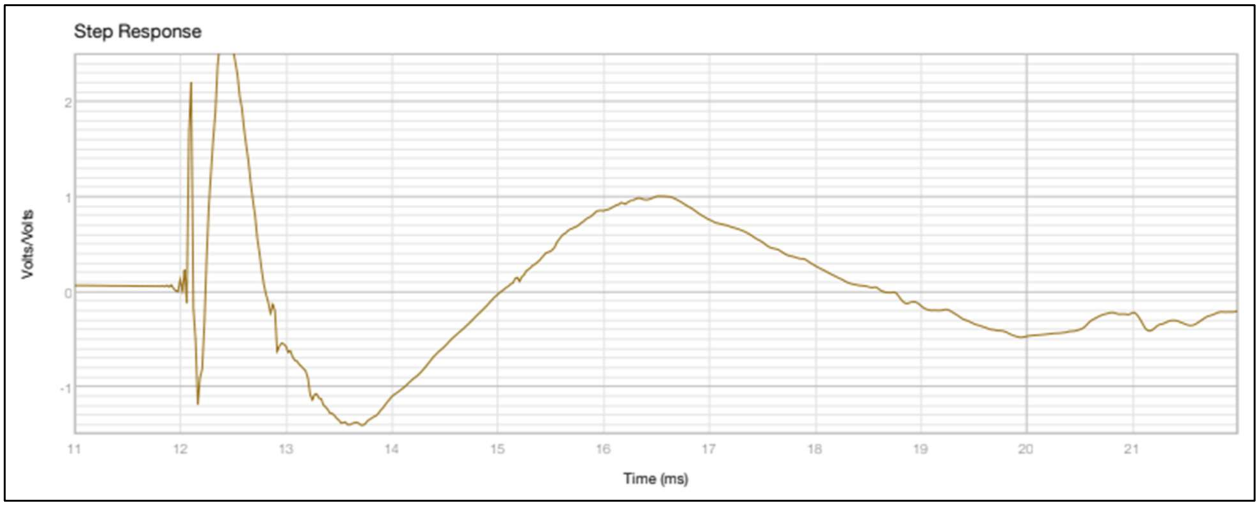


Figure 7 - step response of right mid/high

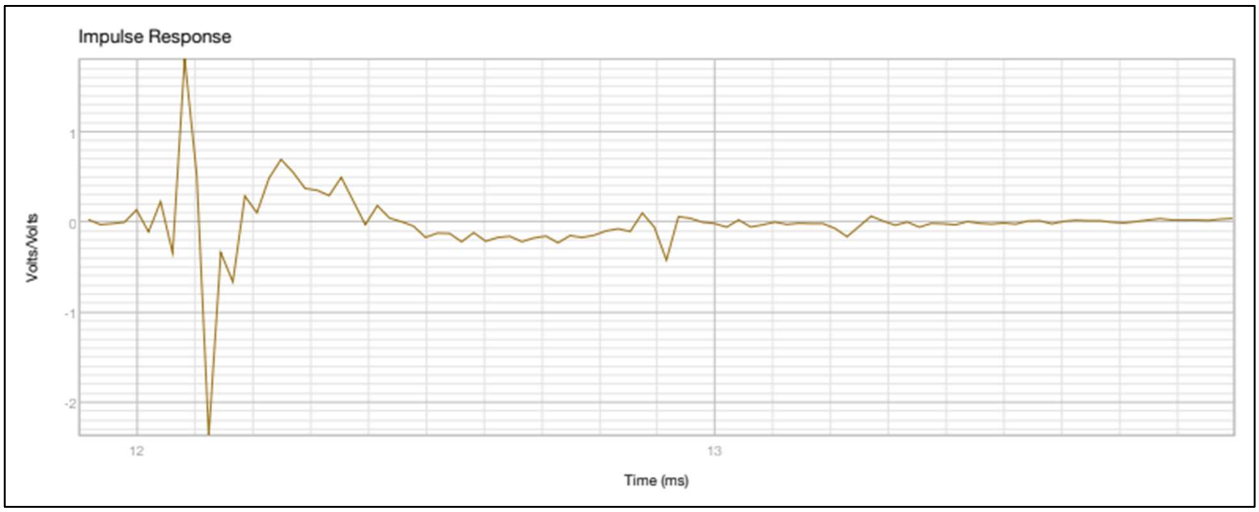


Figure 8 - impulse response of right mid/high

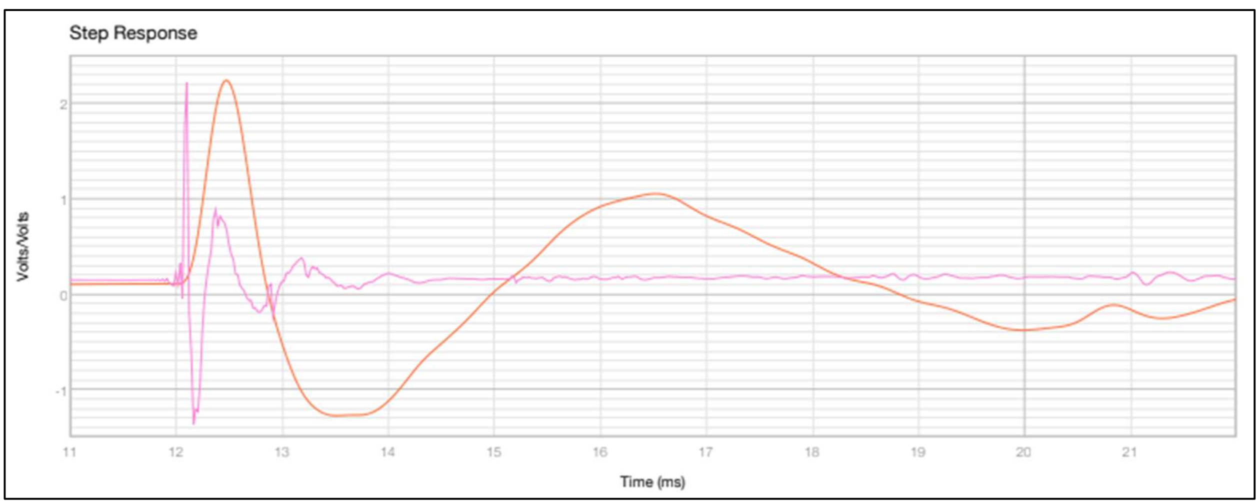


Figure 9 - integraed step response of right mid/high

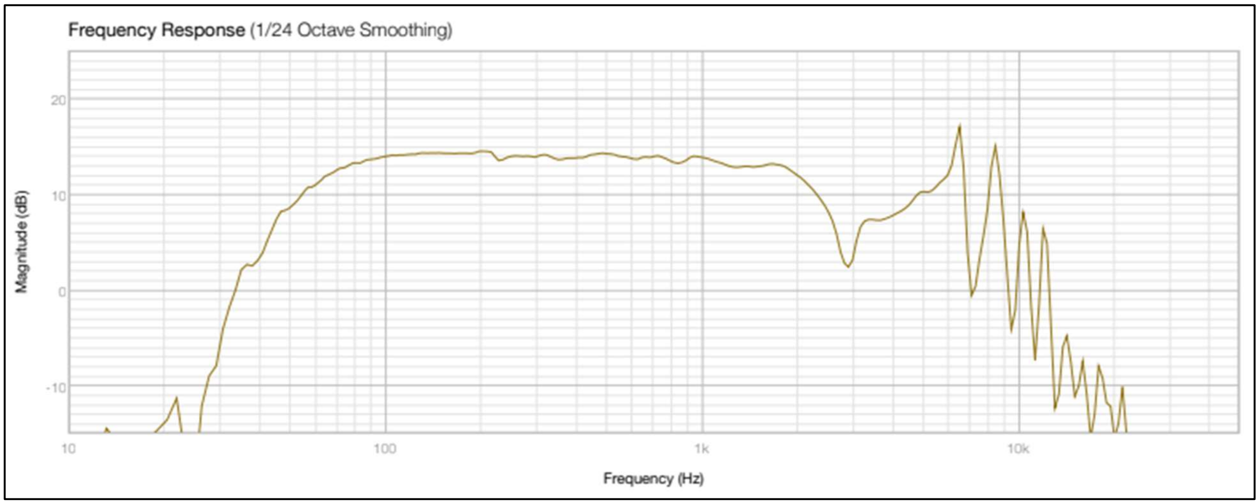


Figure 10 - woofer, no eq, no crossover, close range

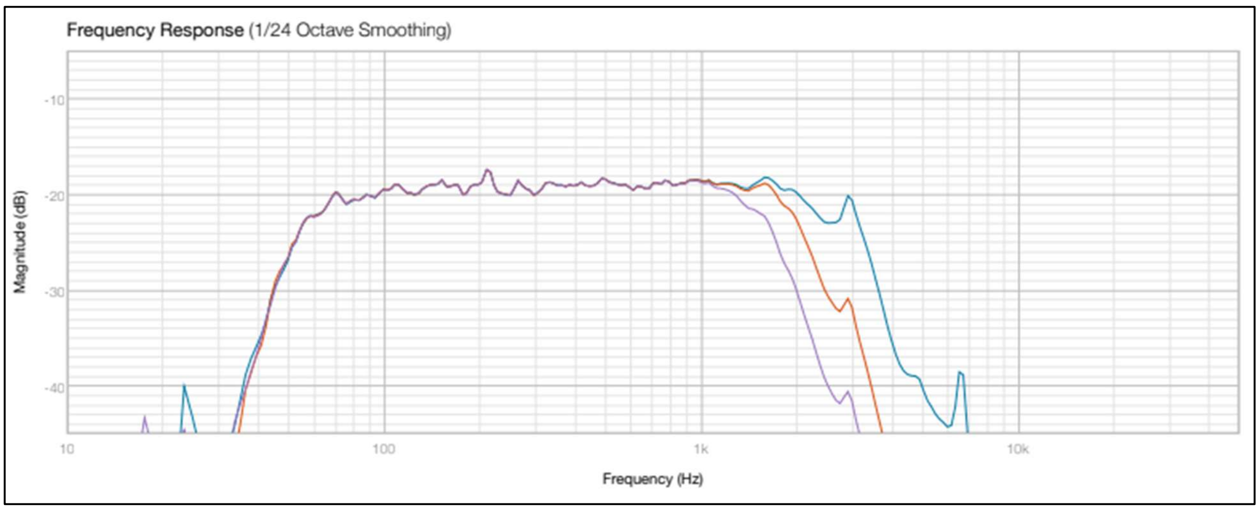


Figure 11 - woofer crossed over at 3000 (blue), 2000 (red), 1500 (purple)

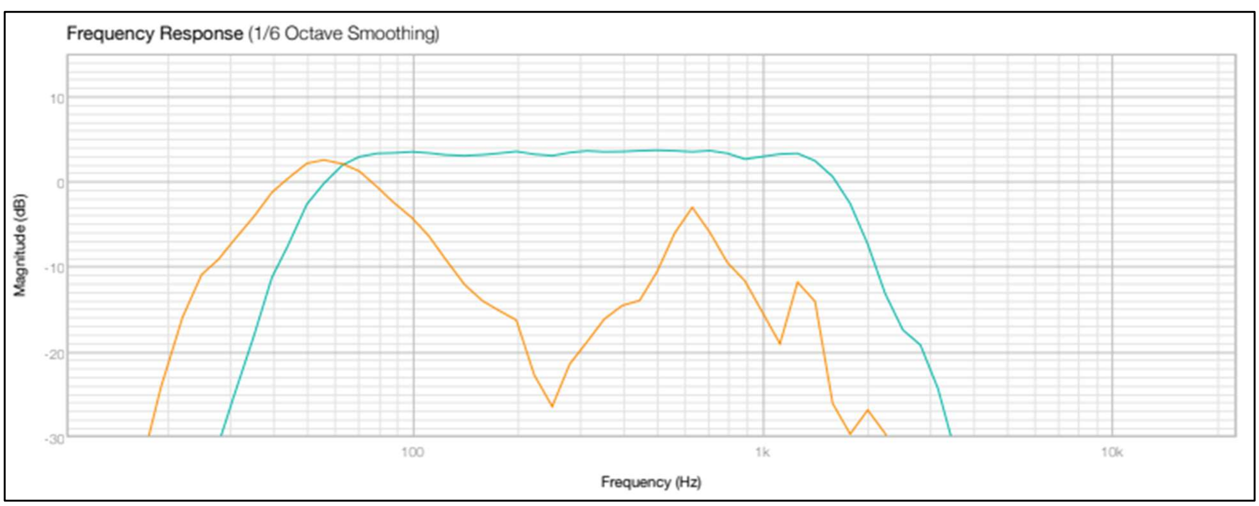


Figure 12 - woofer (blue) compared with port (orange)

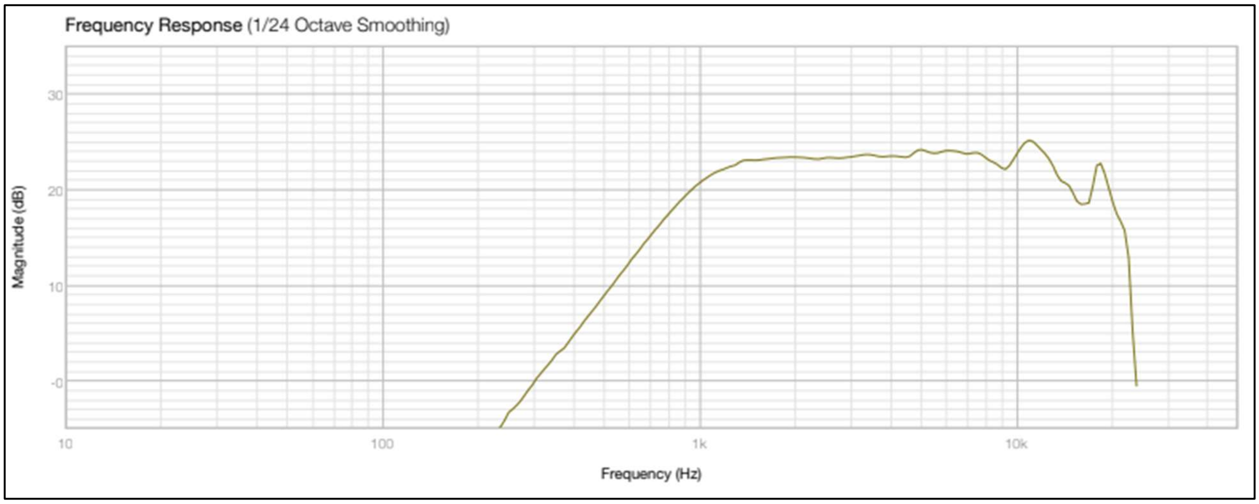


Figure 13 - tweeter, no eq, crossover at 1100 Hz, close range

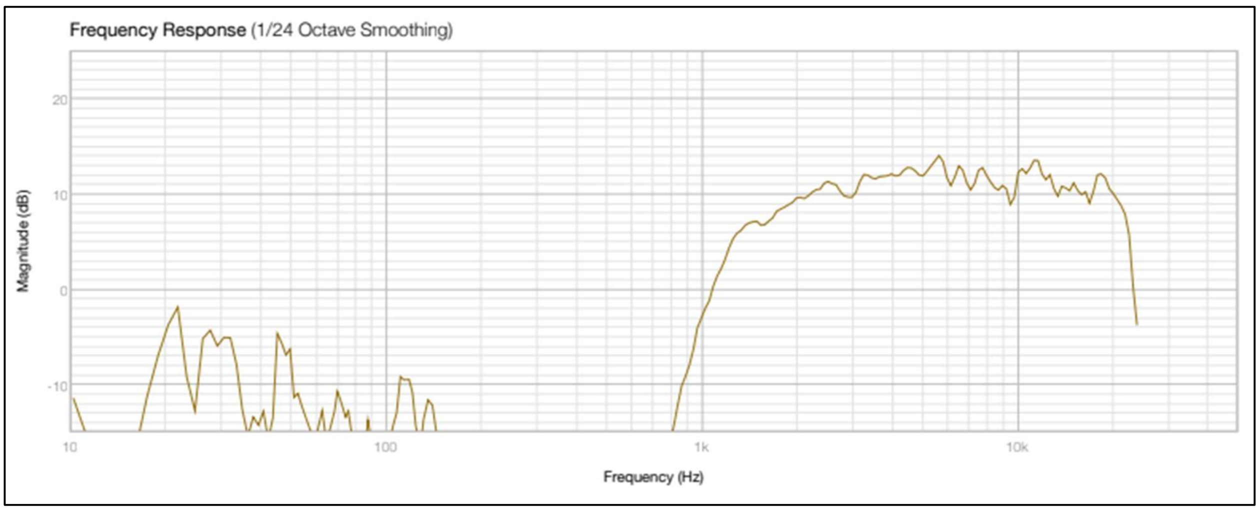


Figure 14 - right tweeter frquency response, 40 dB amplitude, tested at 20 inches

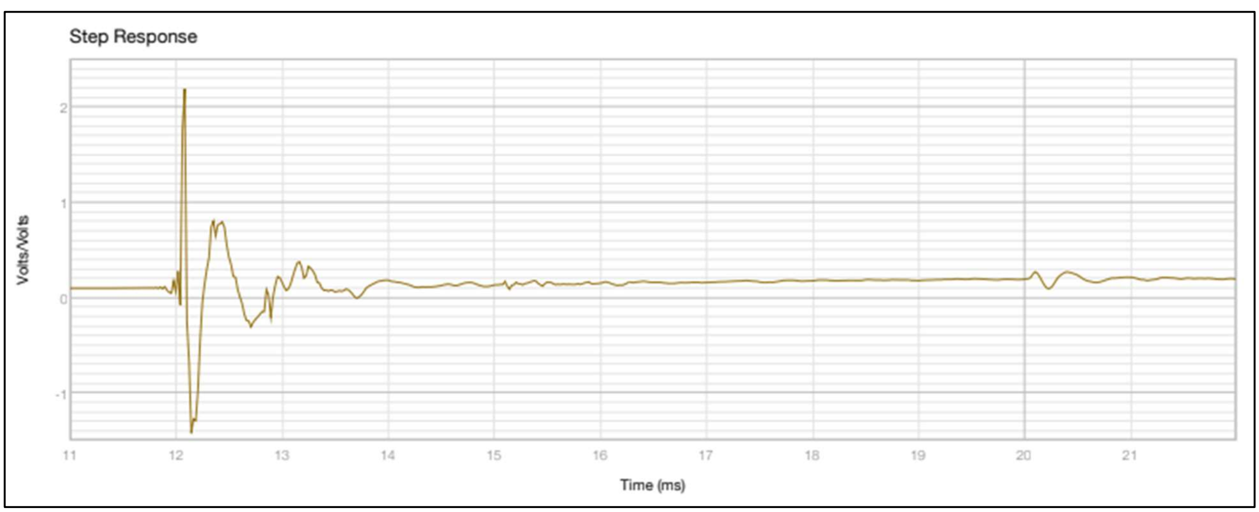


Figure 15 - right tweeter step response

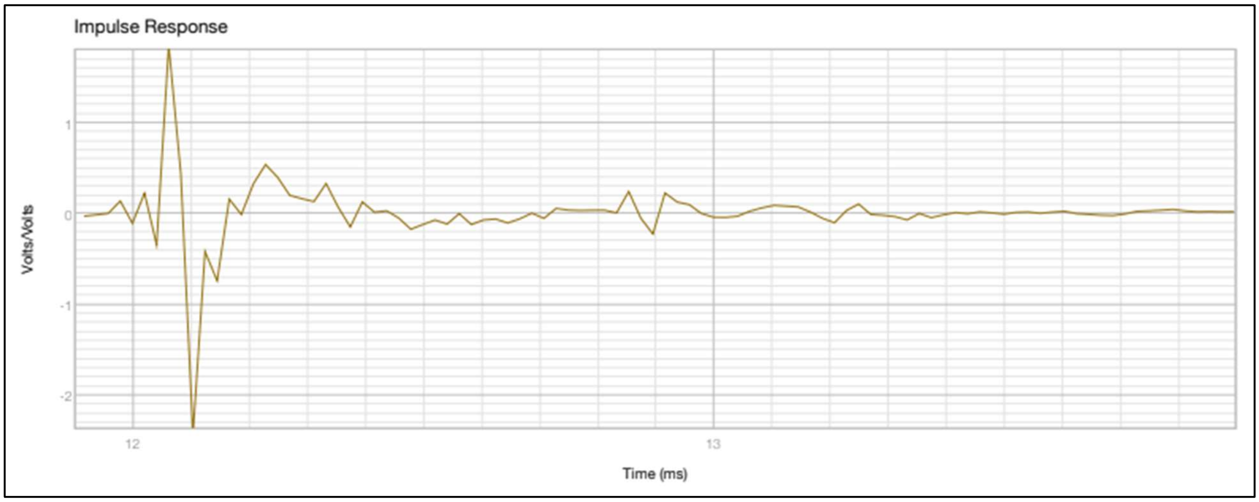


Figure 16 - right tweeter impulse response

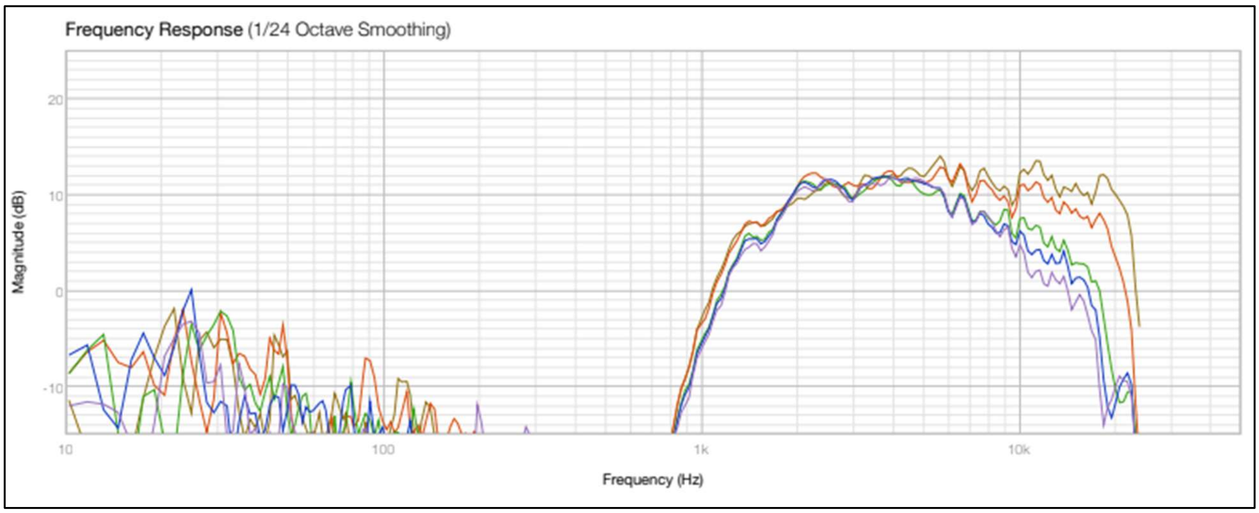


Figure 17 - right tweeter vertical off axis, 40 dB amplitude, tested at 20 inches

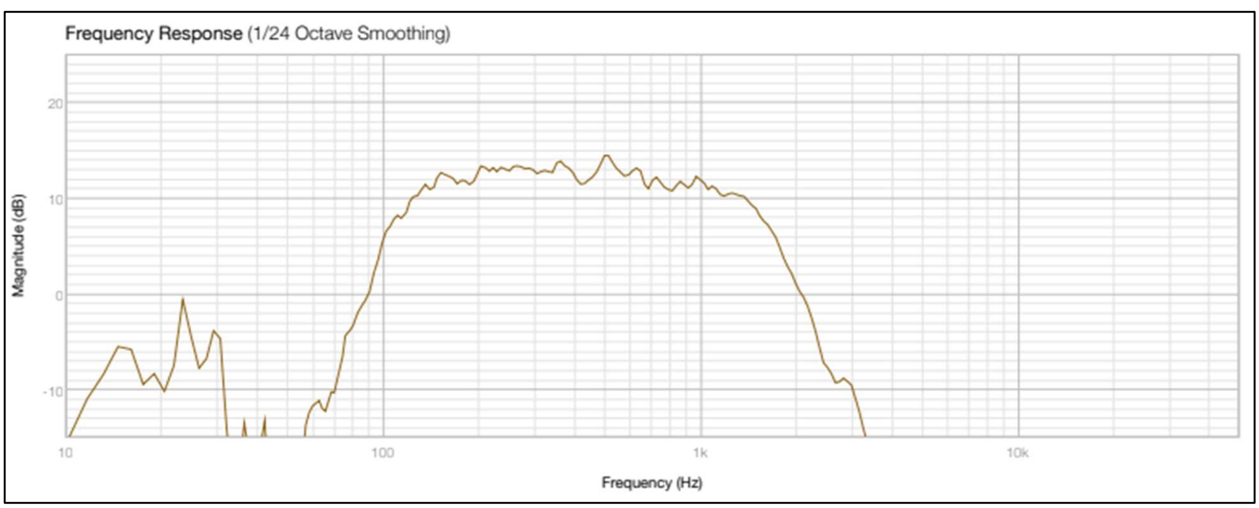


Figure 18 - right woofer frequency response, 40 dB amplitude, tested at 20 inches

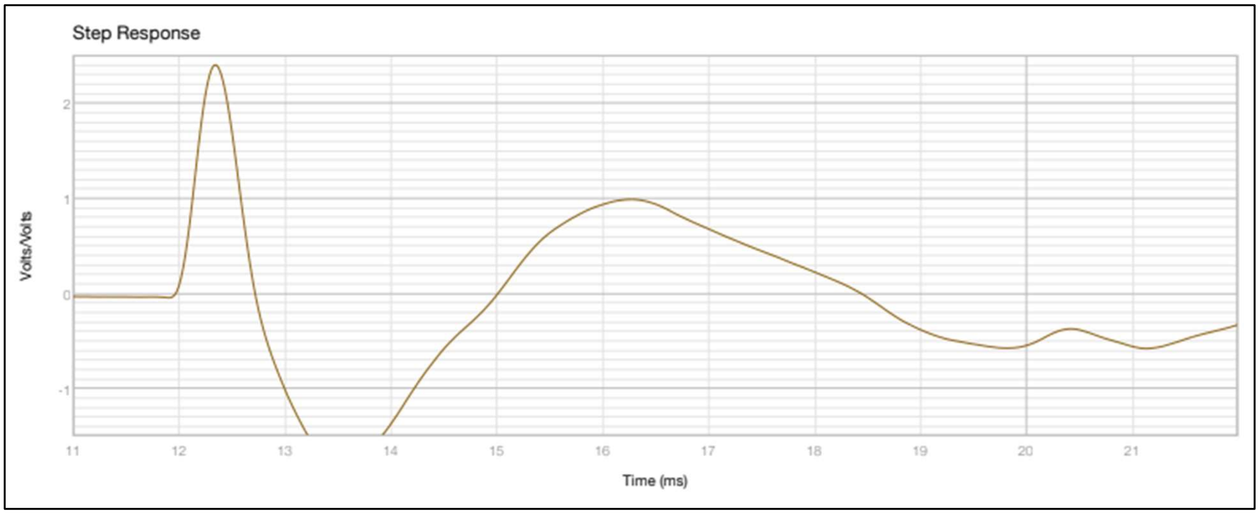


Figure 19 - right woofer step response

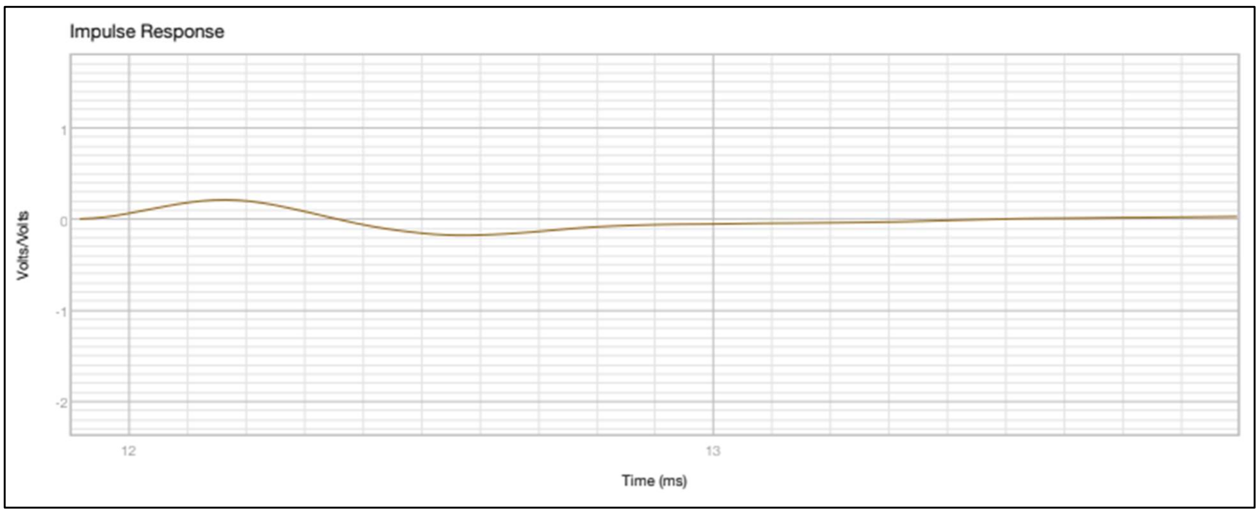


Figure 20 right woofer impulse response

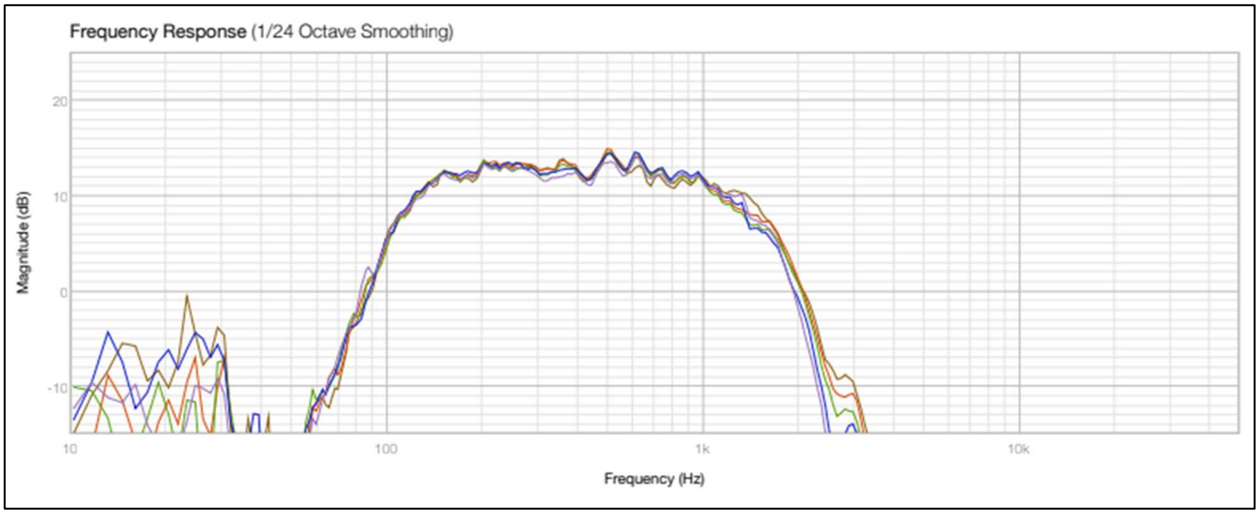


Figure 21 - right woofer vertical off axis response, 40 dB amplitude, tested at 20 inches

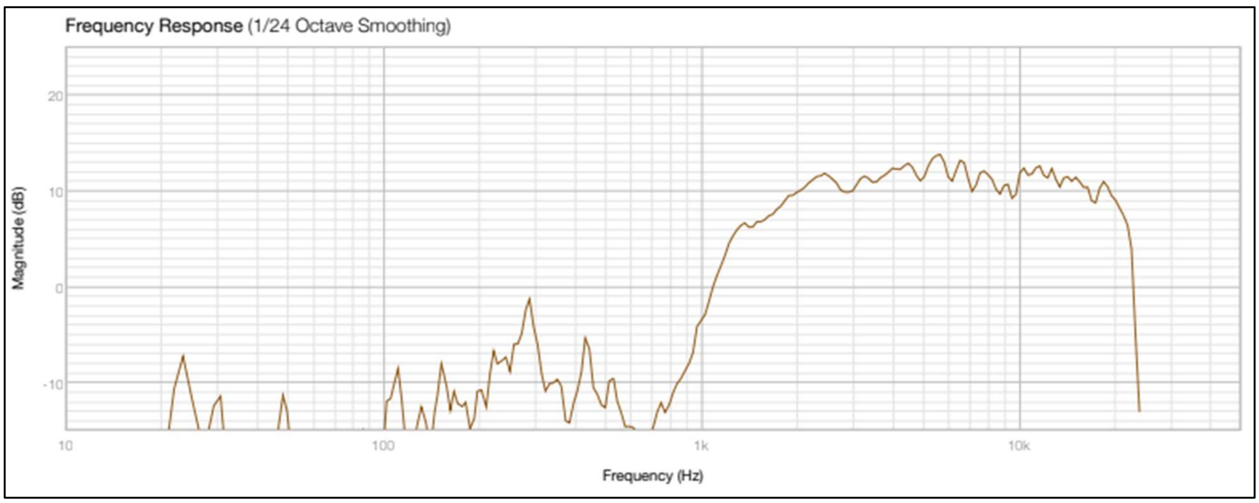


Figure 22 - left tweeter frequency response, 40 dB amplitude, tested at 20 inches

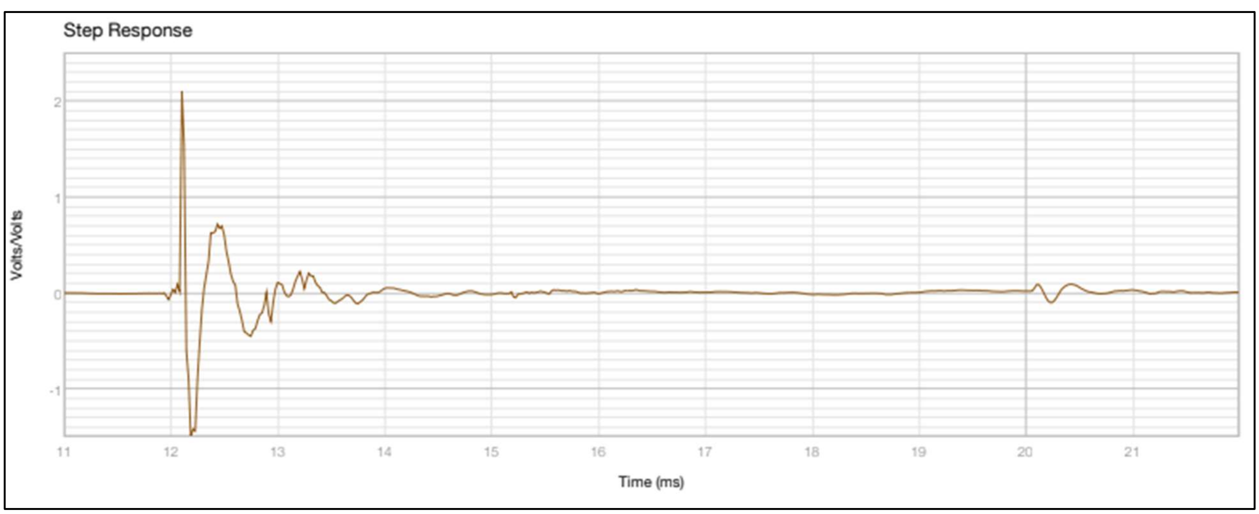


Figure 23 - left tweeter step response

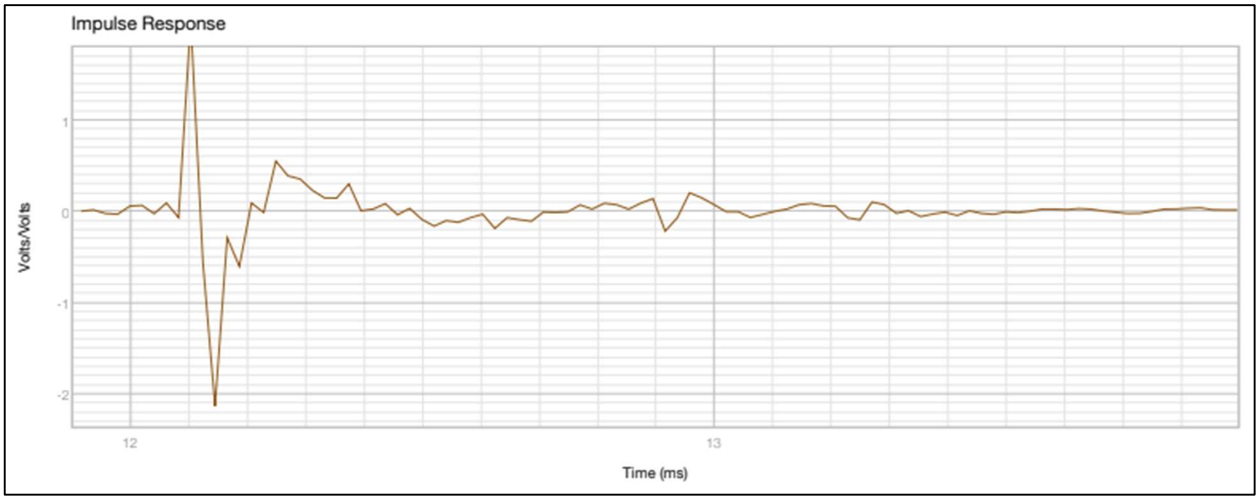


Figure 24 -left tweeter impulse response

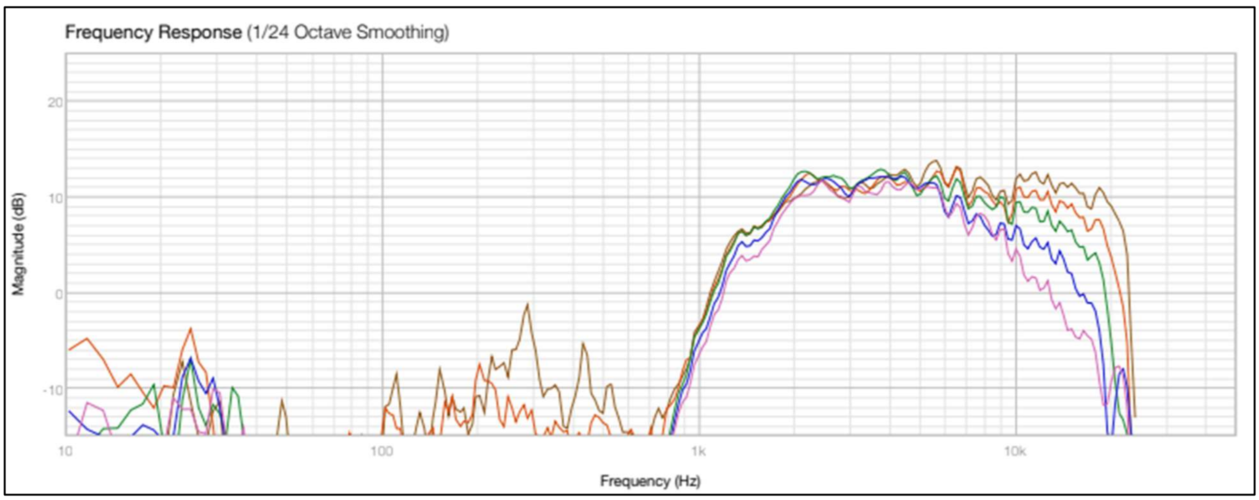


Figure 25 - left tweeter vertical off axis response, 40 dB amplitude, tested at 20 inches

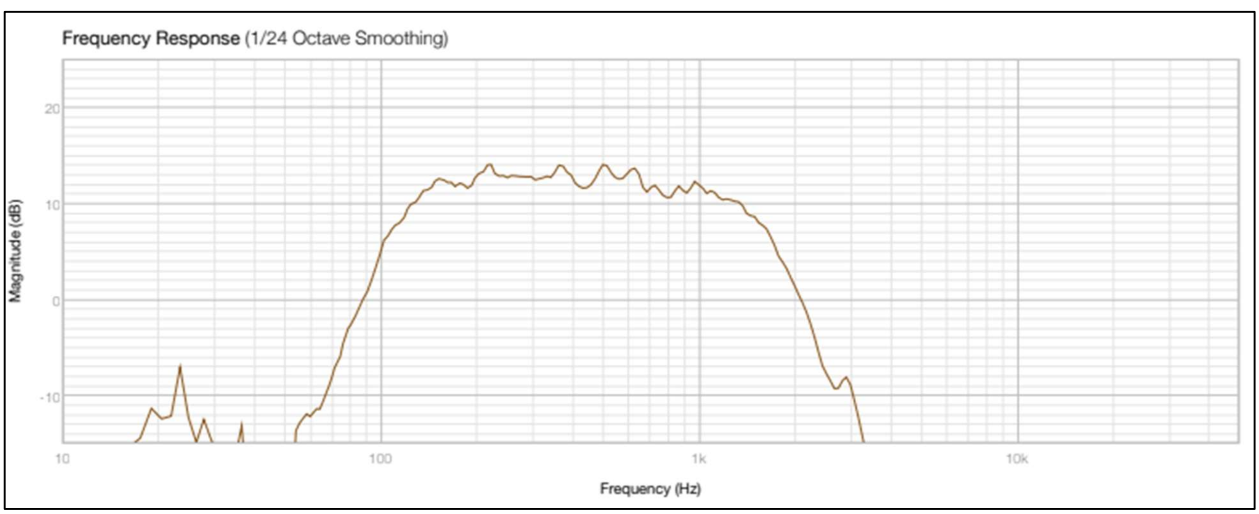


Figure 26 - left woofer frequency response, 40 dB amplitude, tested at 20 inches

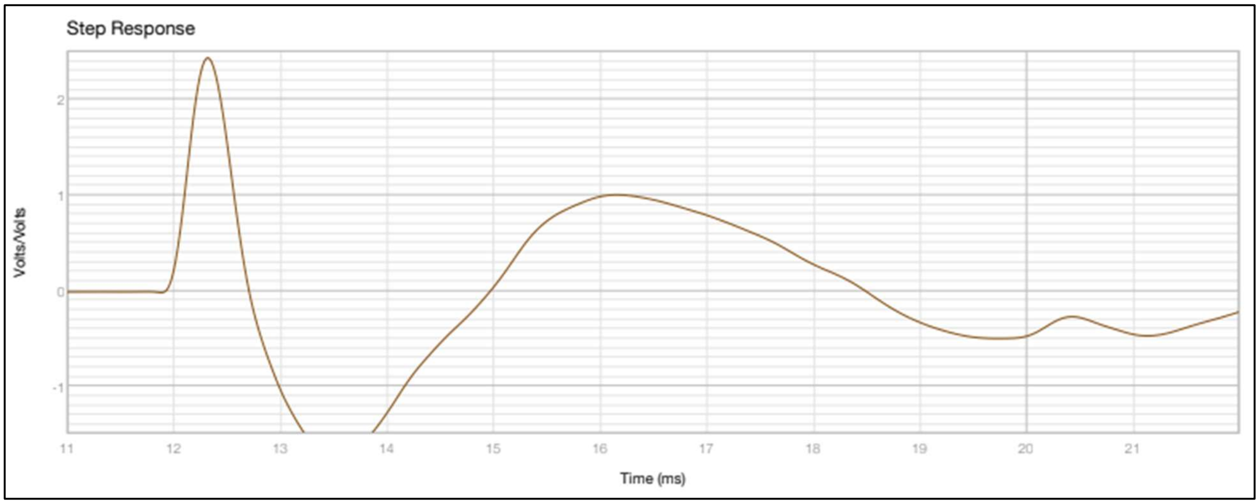


Figure 27 - left woofer step response

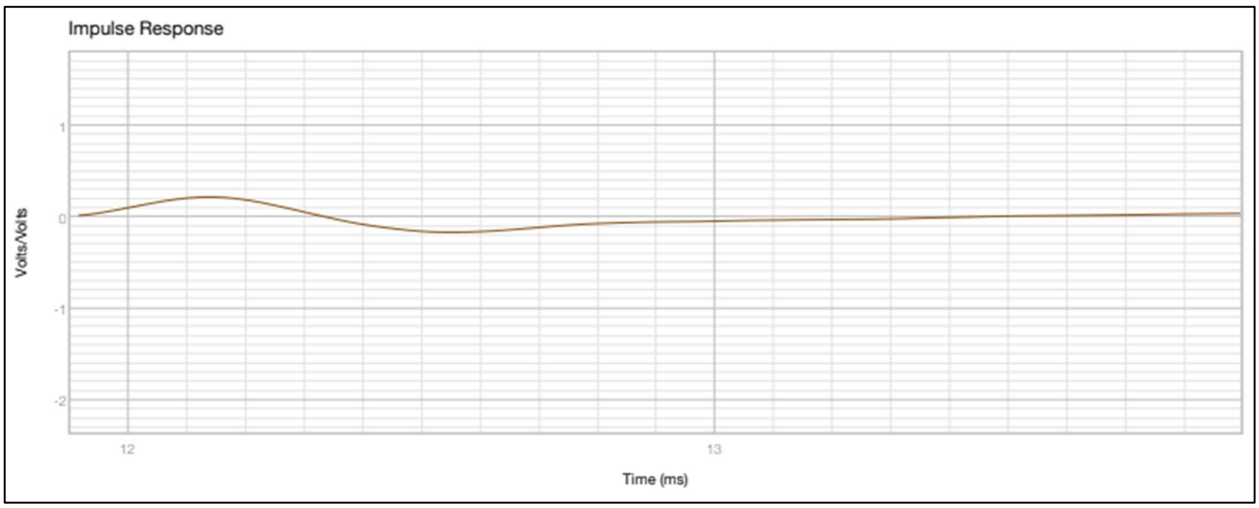


Figure 28 - left woofer impulse response

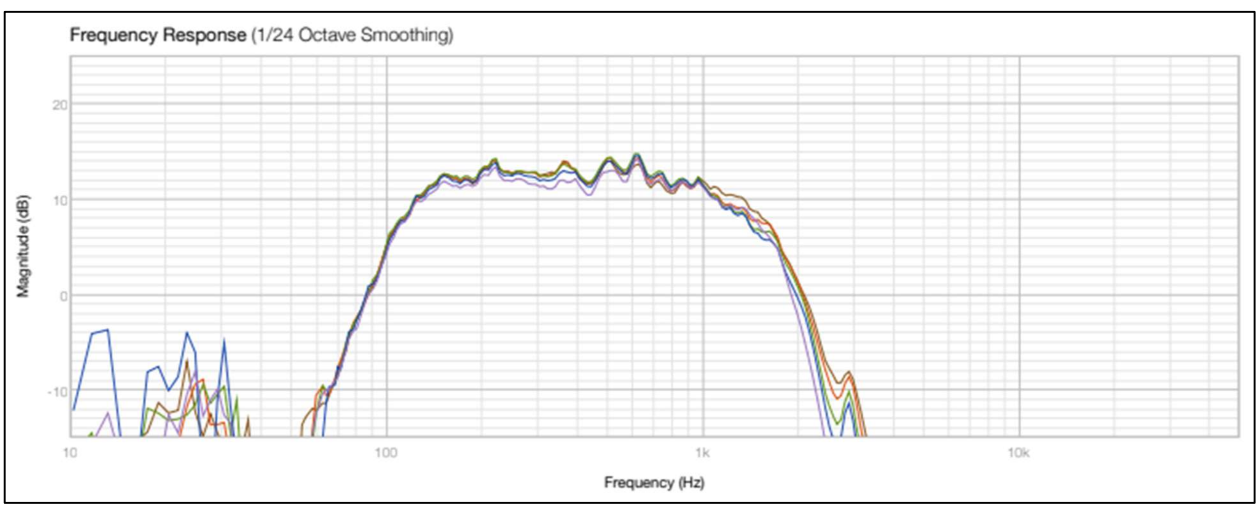


Figure 29 -left woofer vertical off axis response, 40 dB amplitude, tested at 20 inches

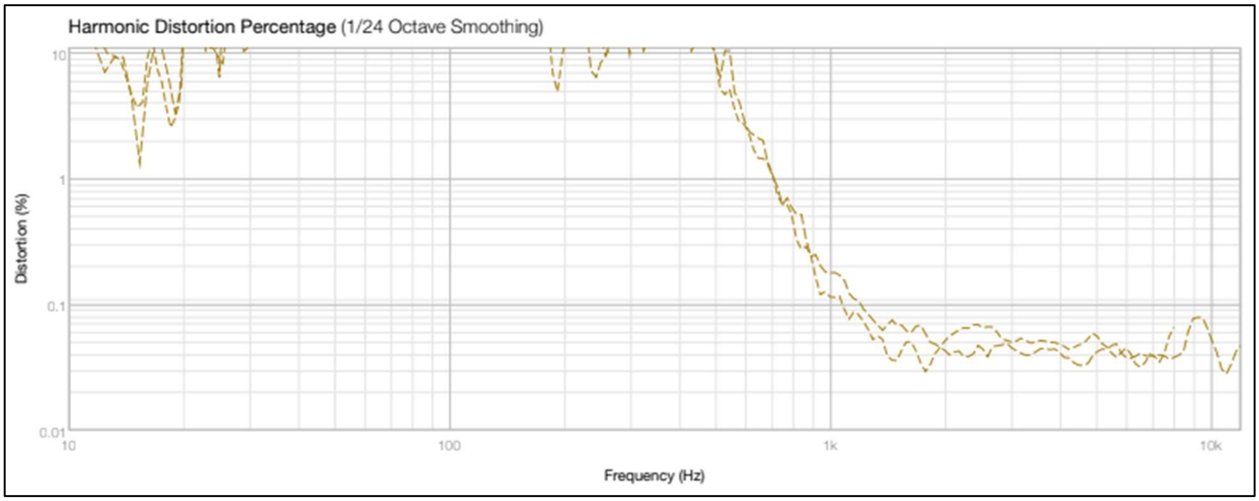


Figure 30 - right tweeter harmonic distortion

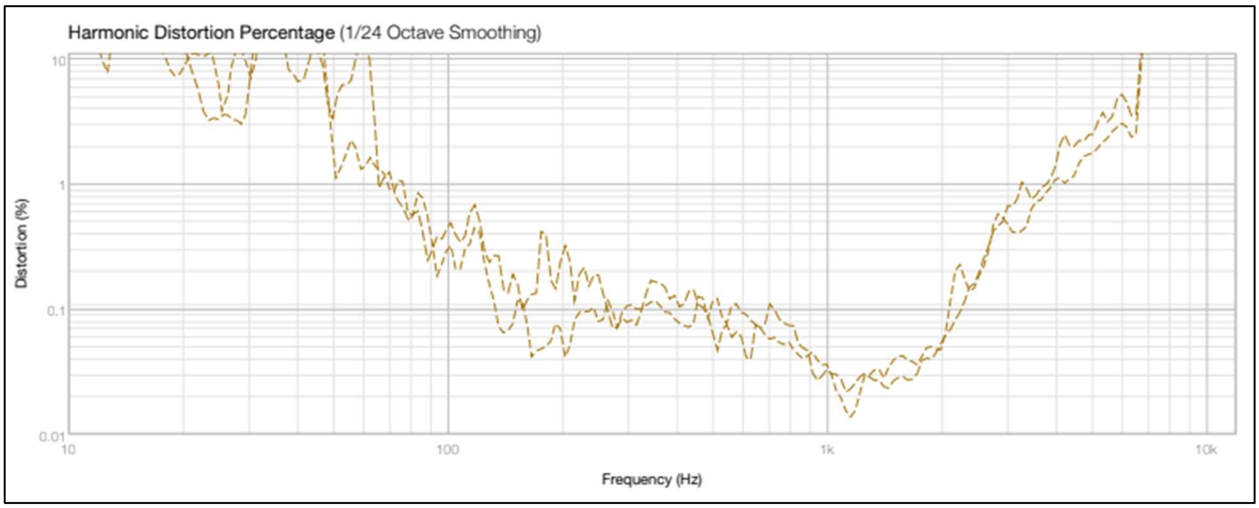


Figure 31 - right woofer harmonic distortion

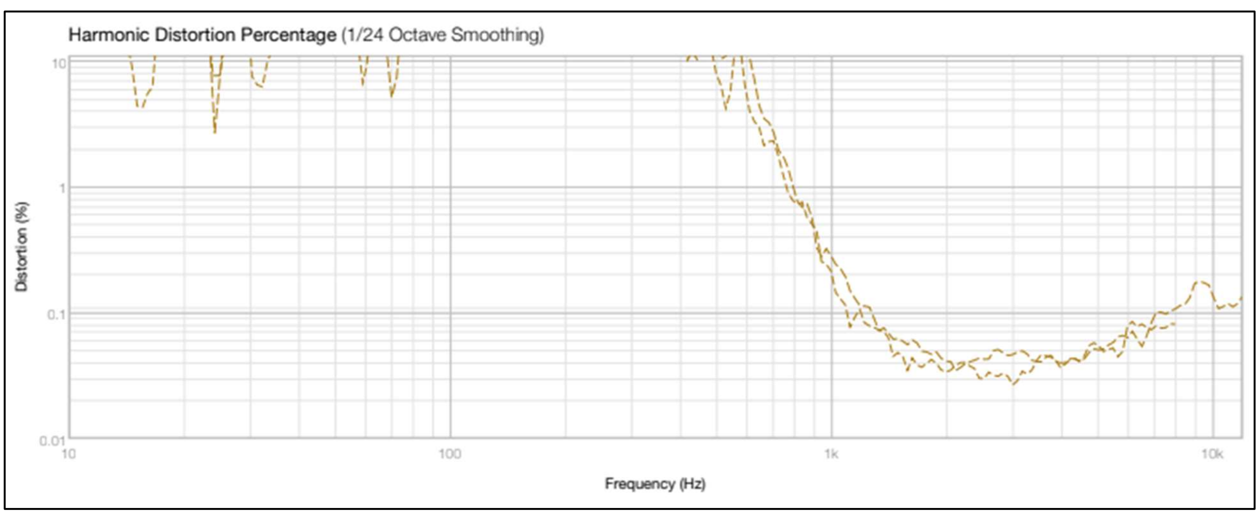


Figure 32 - left tweeter harmonic distortion

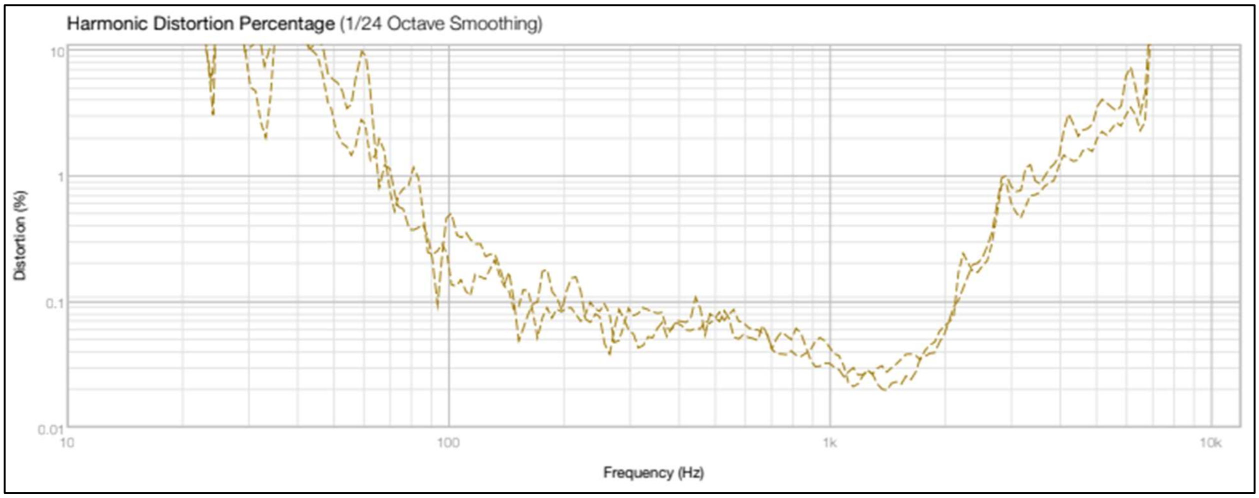


Figure 33 - left woofer harmonic distortion

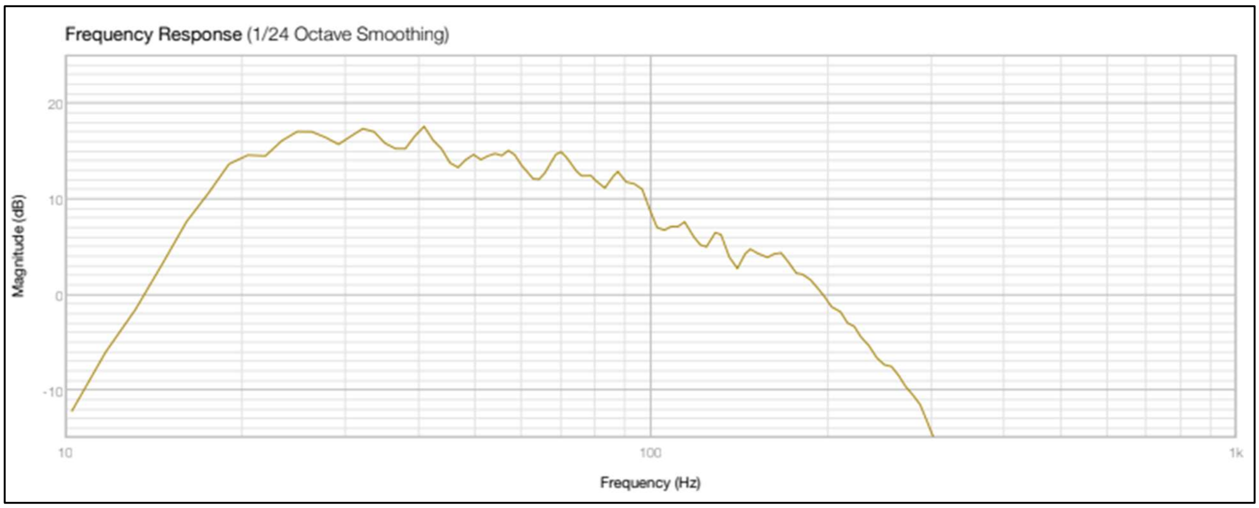


Figure 34 - left subwoofer frequency response, 40 dB amplitude

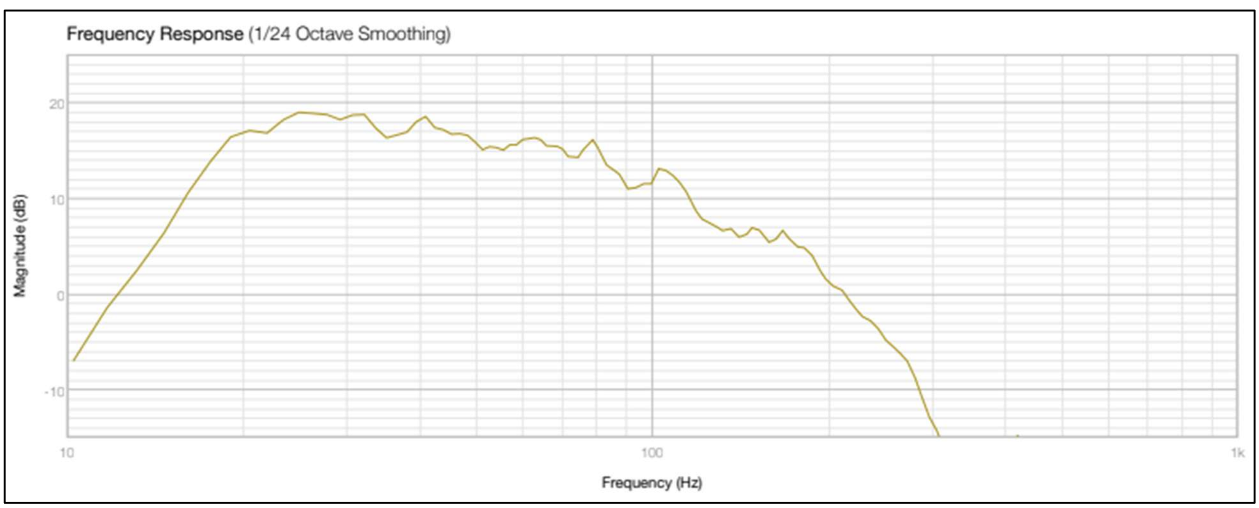


Figure 35 - right subwoofer frequency response, 40 dB amplitude

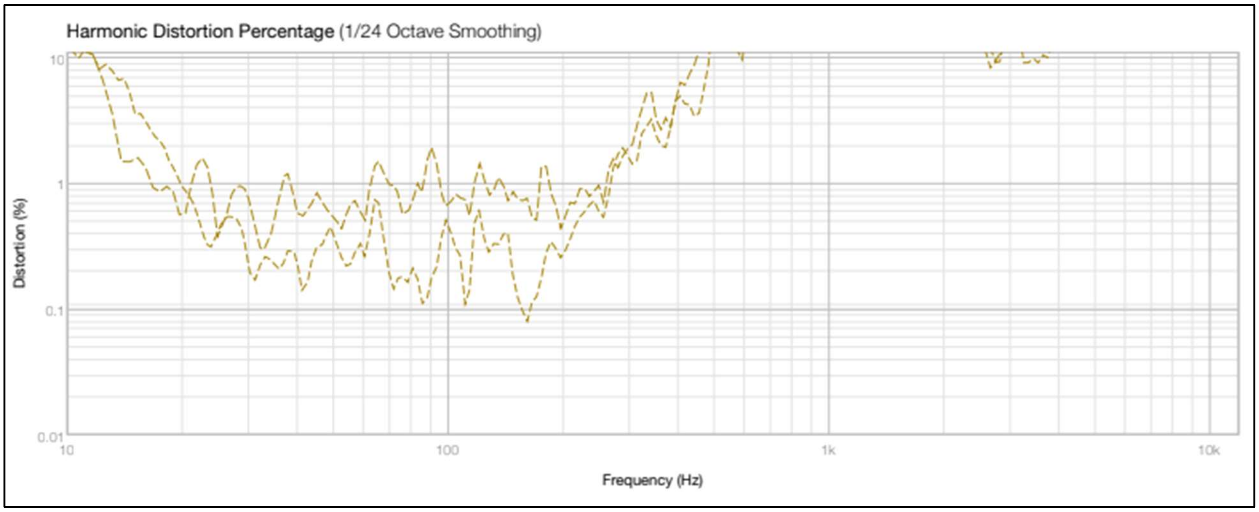


Figure 36 - left subwoofer harmonic distortion

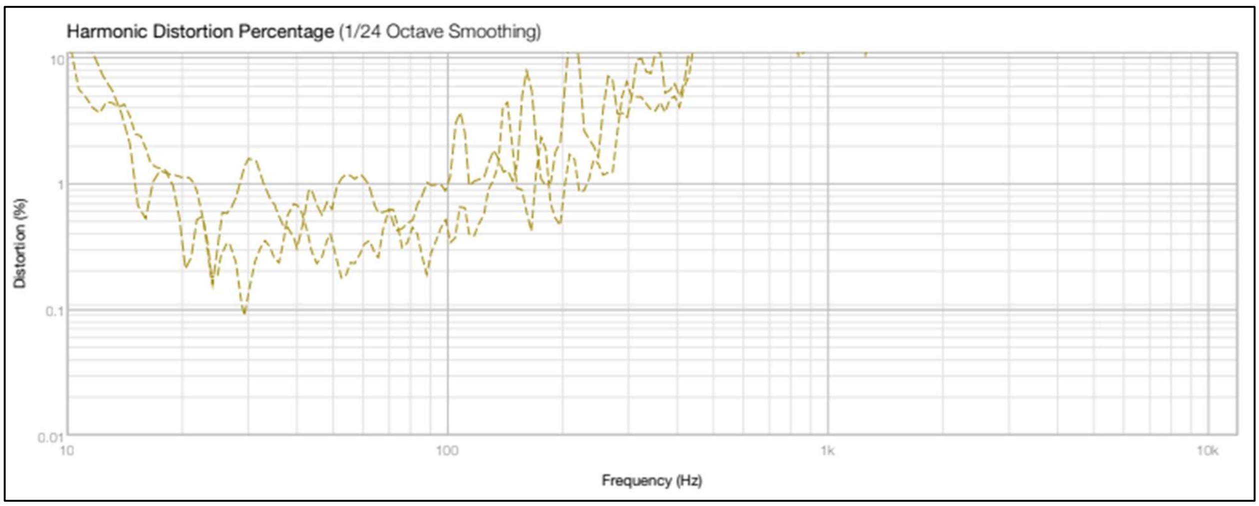


Figure 37 - right subwoofer harmonic distortion

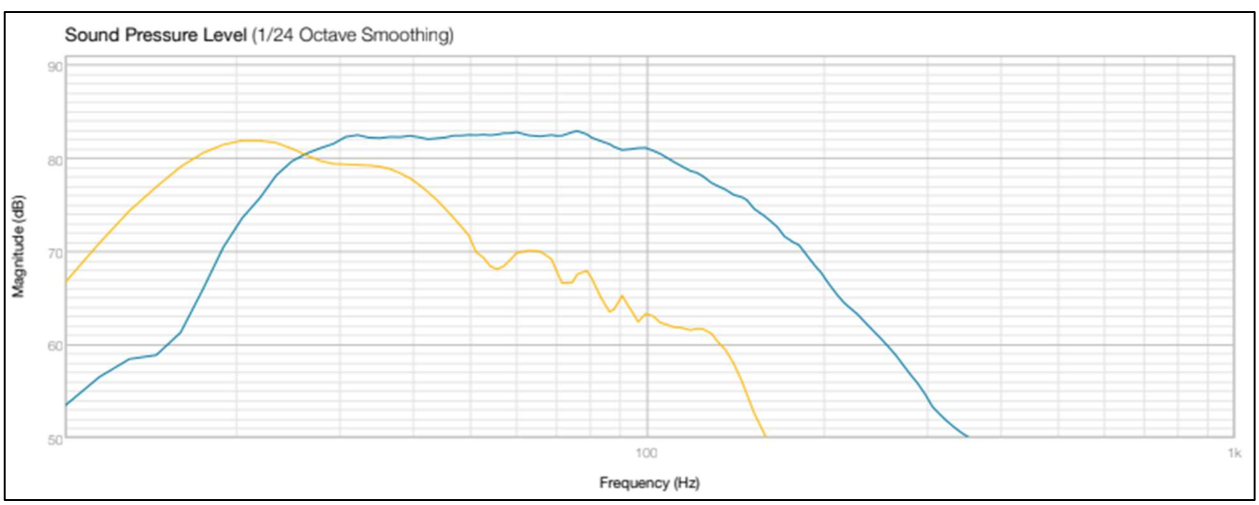


Figure 38 - right subwoofer (blue) compared with port (yellow), close range

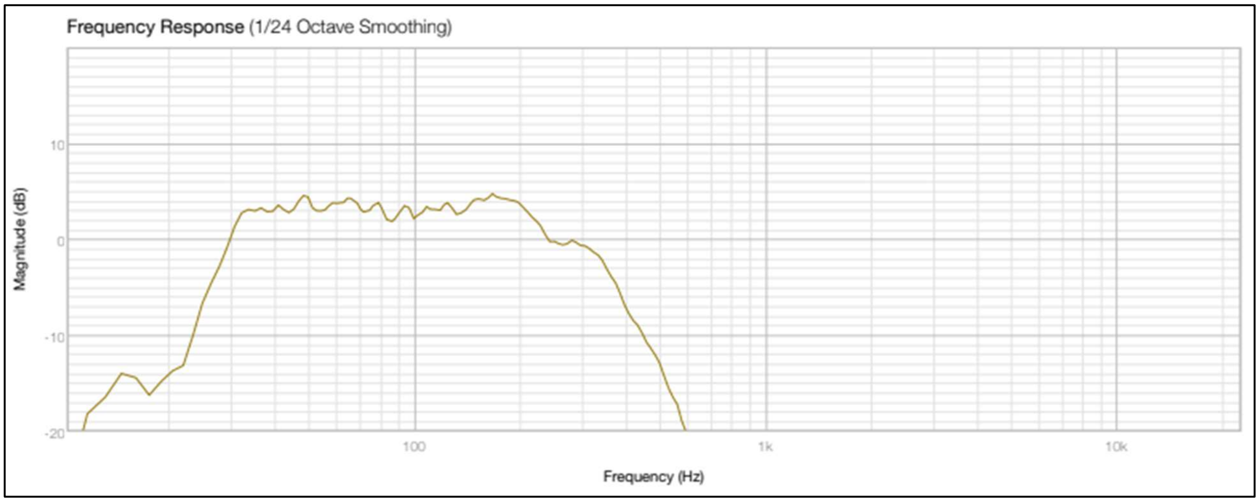


Figure 39 - left subwoofer with no port inserted

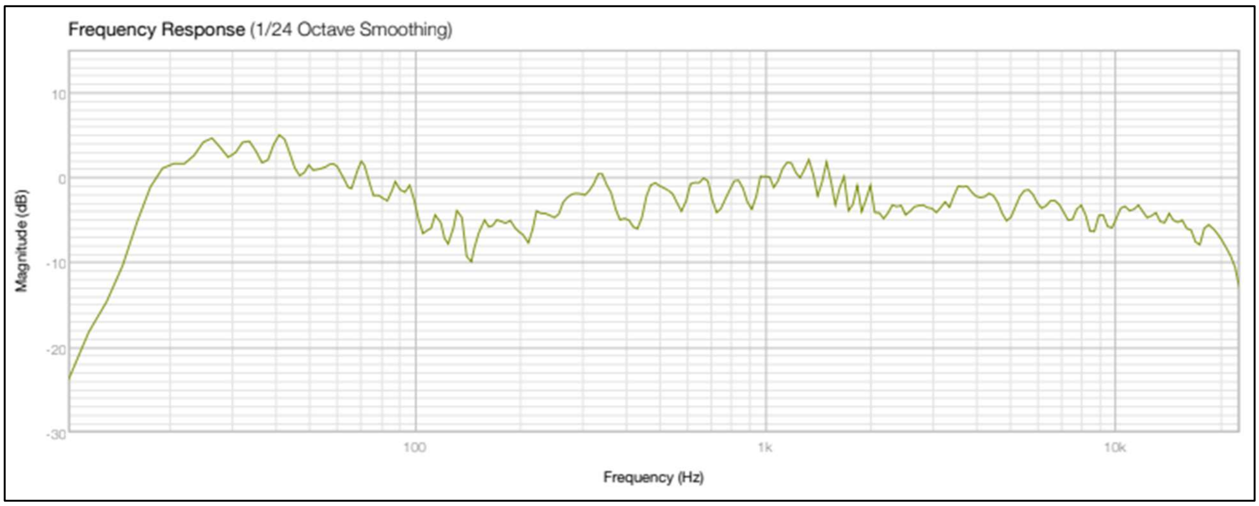


Figure 40 - full system test

Appendix C – Vectorworks Drafting Packet

Transducer Theory

Cabinet Construction

Ace Hobbs

Notes:

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

Cover Page

1-1/2" = 1'

One Printer Page

Plate 1

Table of Contents

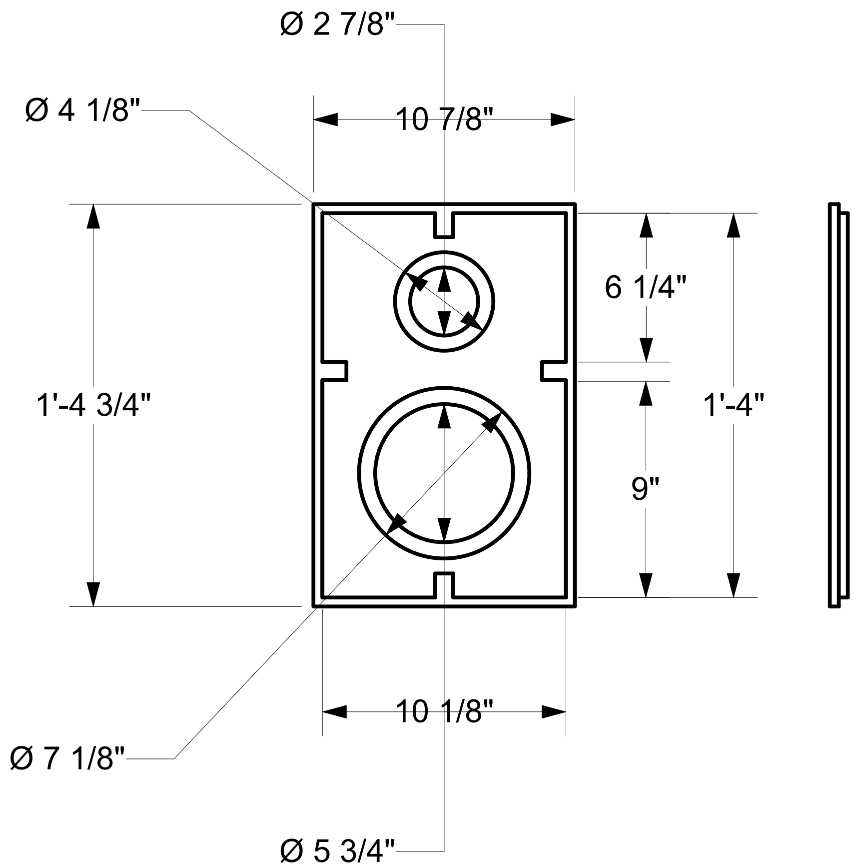
Notes:

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs
Table of Contents
1-1/2" = 1'
One Printer Page

Plate 2

Vectorworks Educational Version



Notes:
Notches are 0.75" x 1"

Tweeter Sunk in 0.17"
Woofer Sunk In 0.2"

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

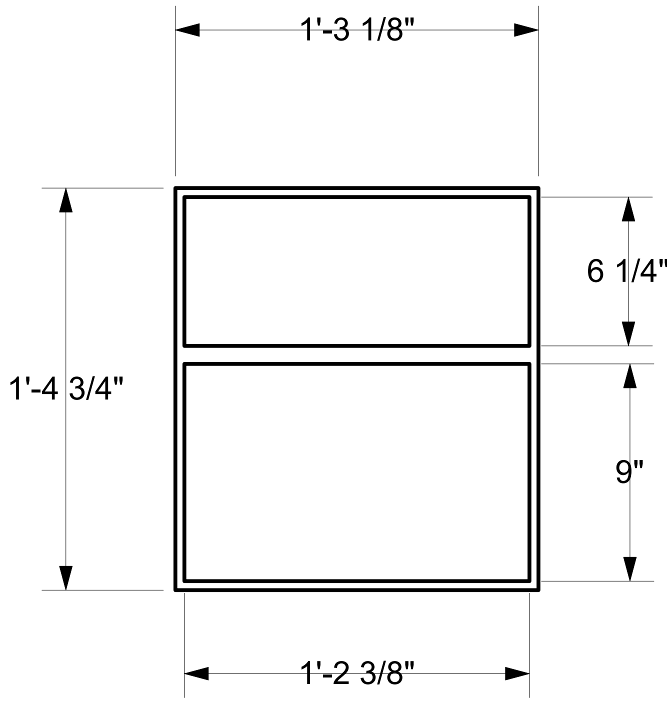
Mid/High - Front Face

1-1/2" = 1'

One Printer Page

Plate 3

Vectorworks Educational Version



Notes:
There needs to be two of these per cabinet

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

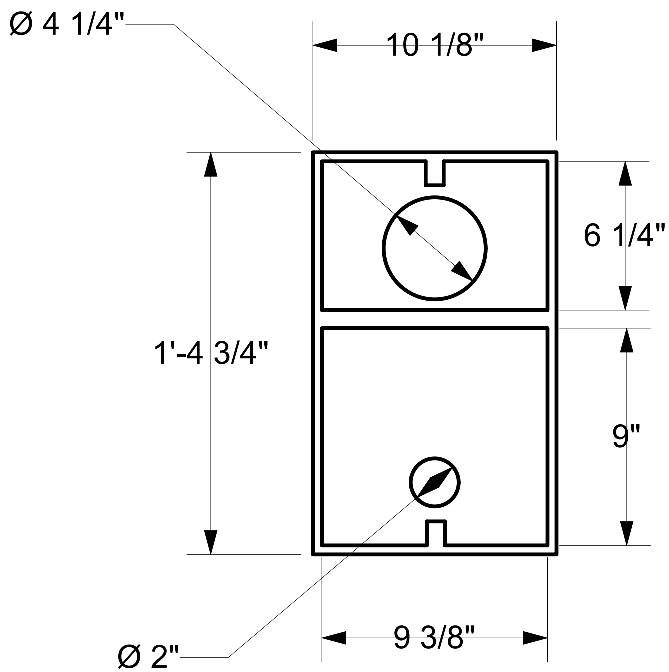
Mid/High - Side Face

1-1/2" = 1'

One Printer Page

Plate 4

Vectorworks Educational Version



Notes:
Notches are same as Front Face

Check NL4 connector dimensions, it sinks in to sit flush

Revision #: / Revision Date:	
1	11/08/23

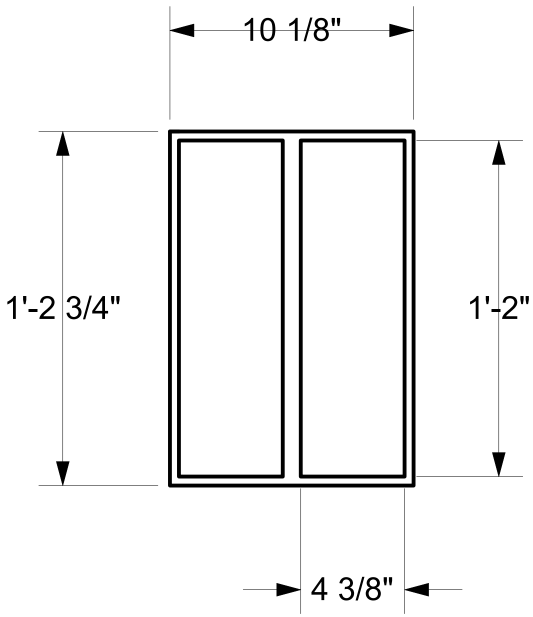
Designer: Ace Hobbs

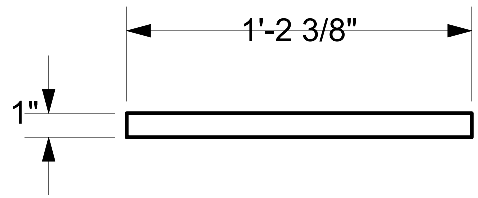
Mid/High - Rear Face

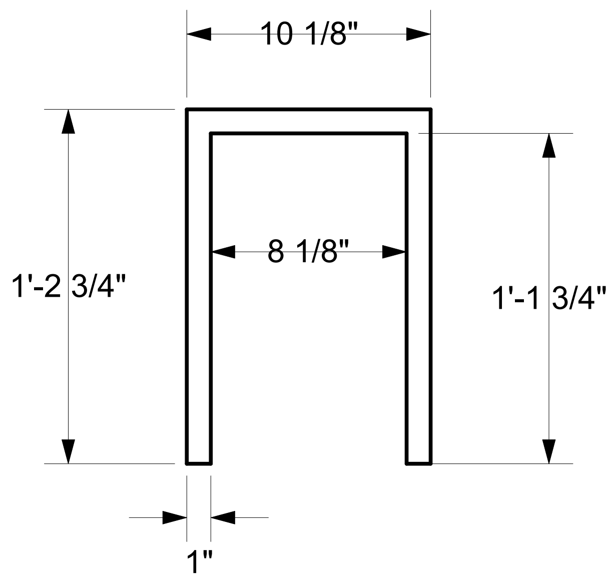
1-1/2" = 1'

One Printer Page

Plate 5







Notes:
Supports are 0.75" thick plywood

Small strip supports need two per cabinet

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

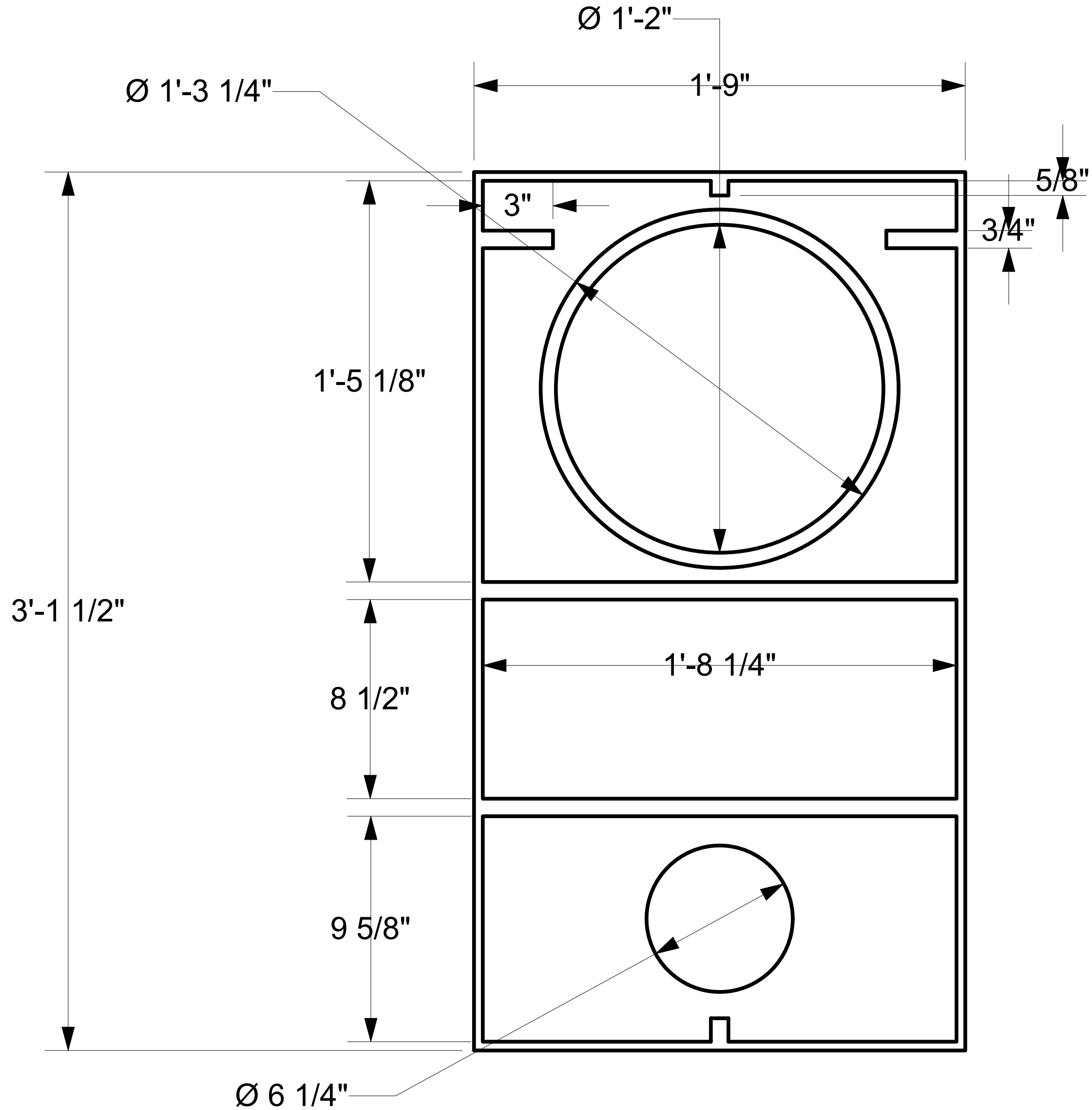
Mid/High - Top/Bot + Supports

1-1/2" = 1'

One Printer Page

Plate 6

Vectorworks Educational Version



Notes:
Bottom notch is 1"

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

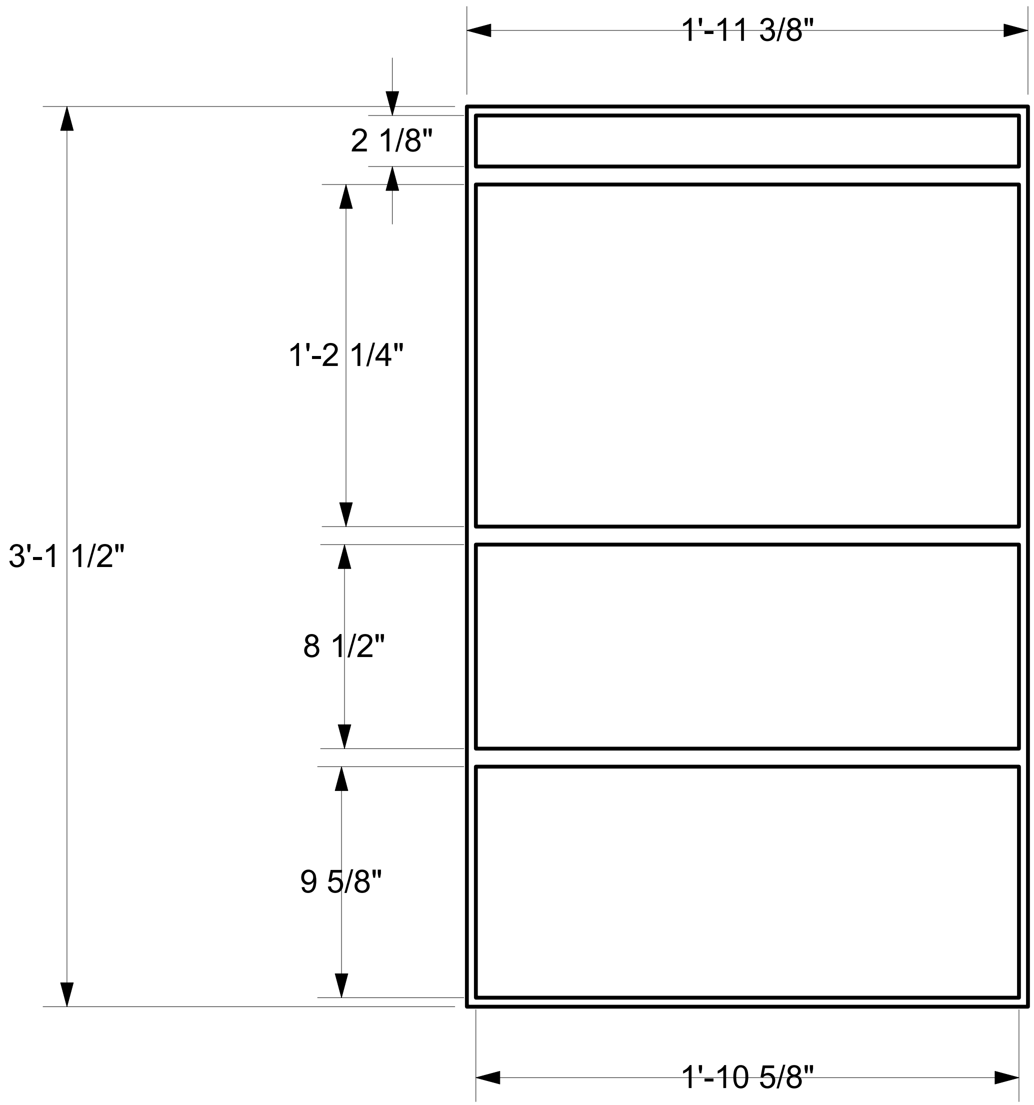
Subwoofer - Front Face

1-1/2" = 1'

One Printer Page

Plate 7

Vectorworks Educational Version



Notes:

Revision #: / Revision Date:	
1	11/08/23

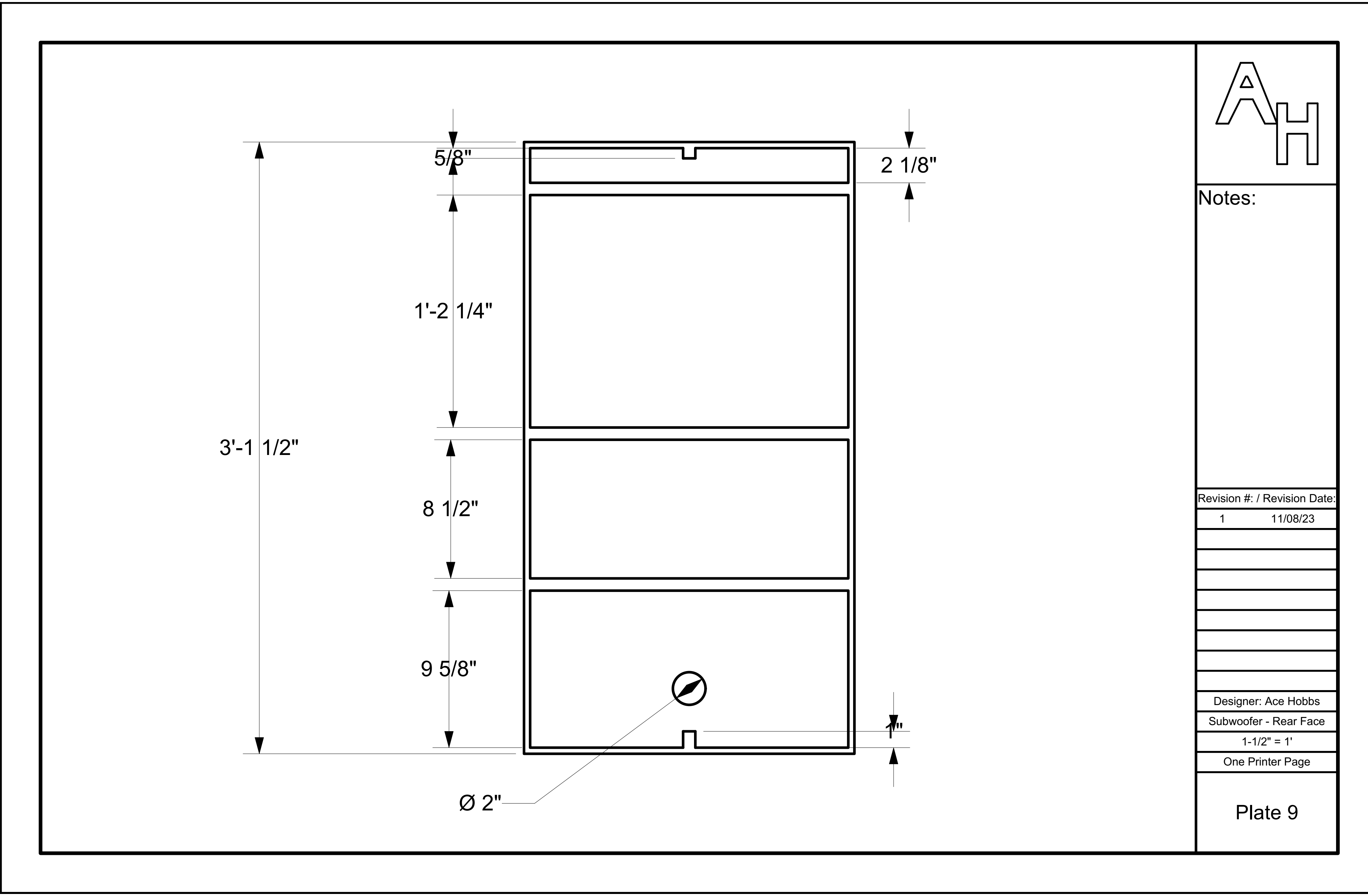
Designer: Ace Hobbs

Subwoofer - Side Face

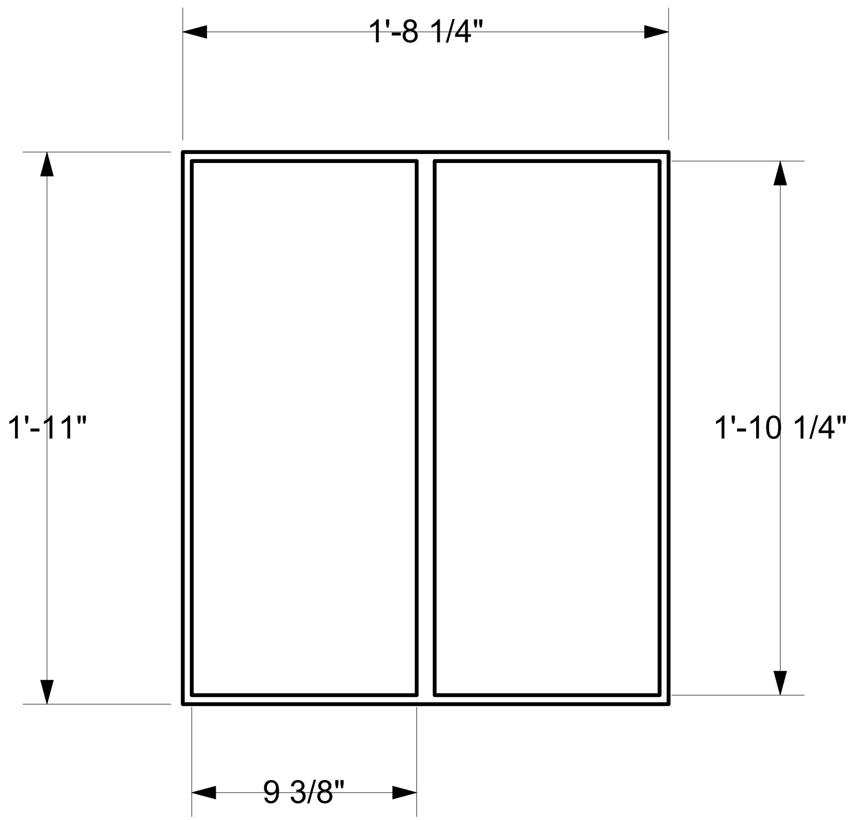
1-1/2" = 1'

One Printer Page

Plate 8



Vectorworks Educational Version



Notes:

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

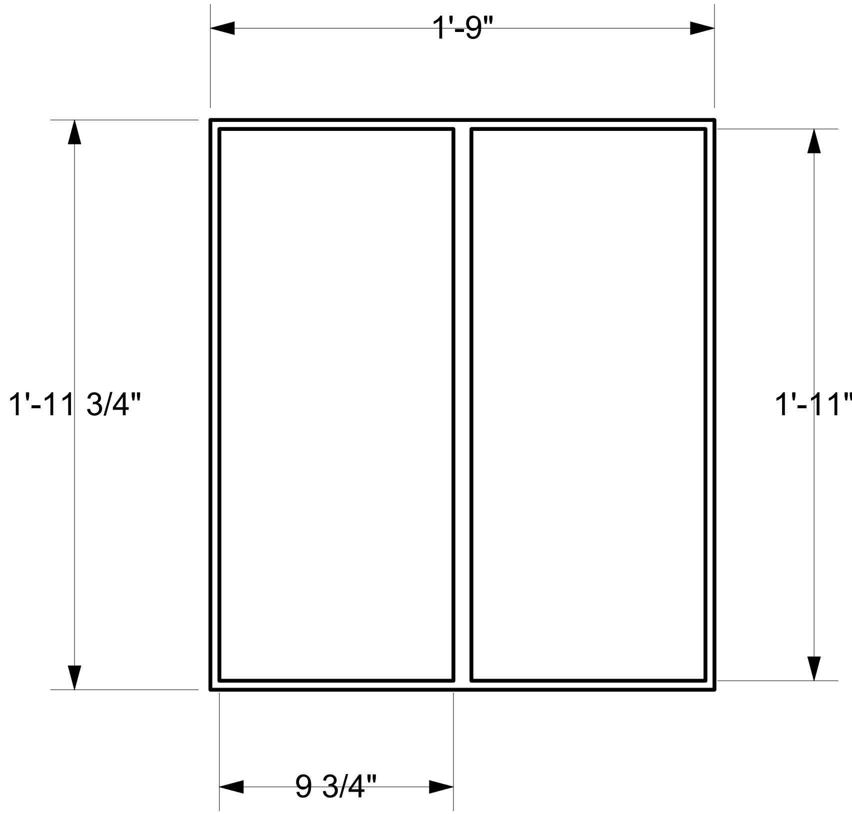
Subwoofer - Bottom Face

1-1/2" = 1'

One Printer Page

Plate 10

Vectorworks Educational Version



Notes:
Extra cutout glued to top for chamfer

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

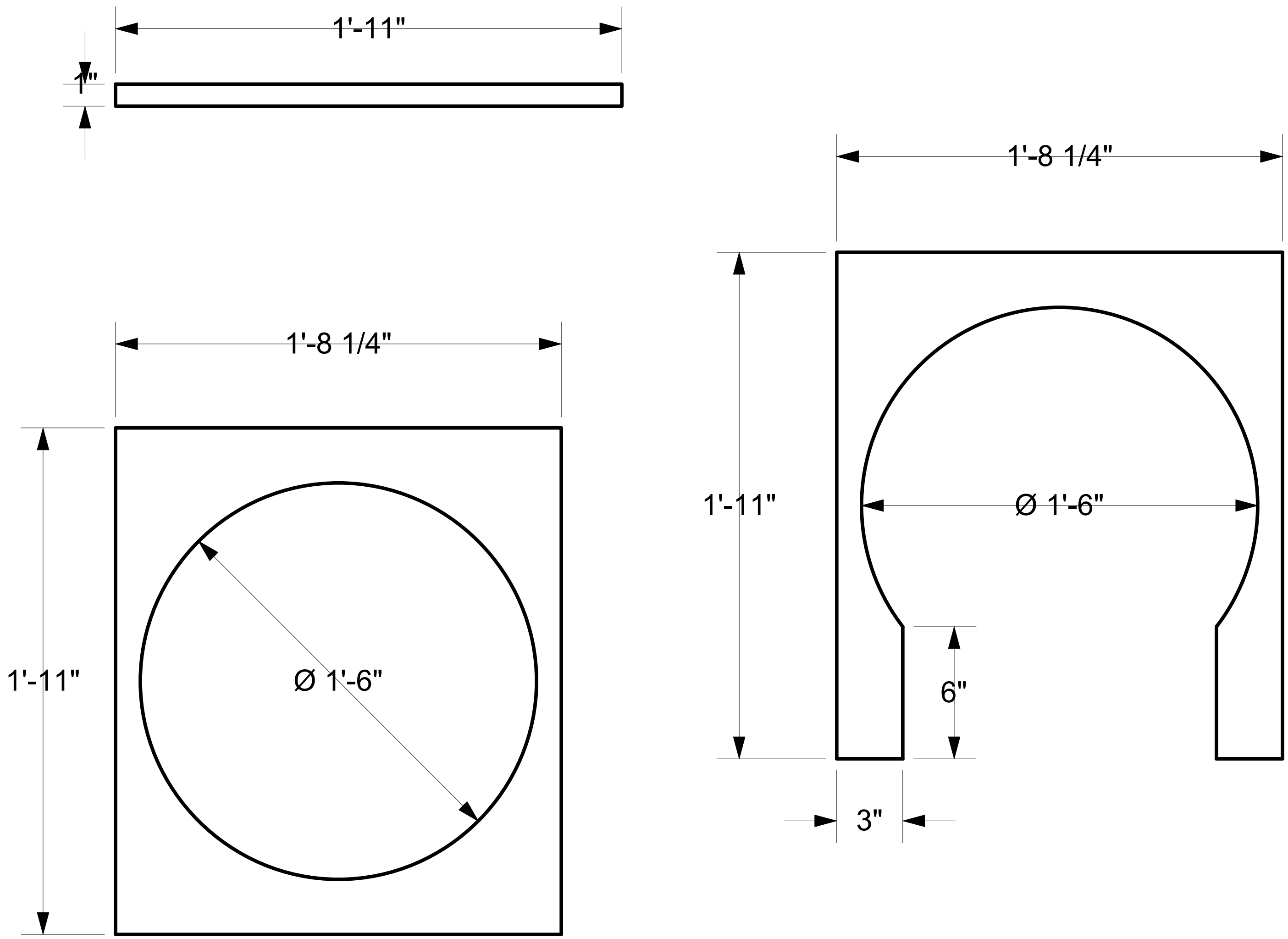
Subwoofer - Top Face

1-1/2" = 1'

One Printer Page

Plate 11

Vectorworks Educational Version



Notes:
There need to be two of the small supports and full circle supports per cabinet
Cut from 3/4" plywood

Revision #: / Revision Date:	
1	11/08/23

Designer: Ace Hobbs

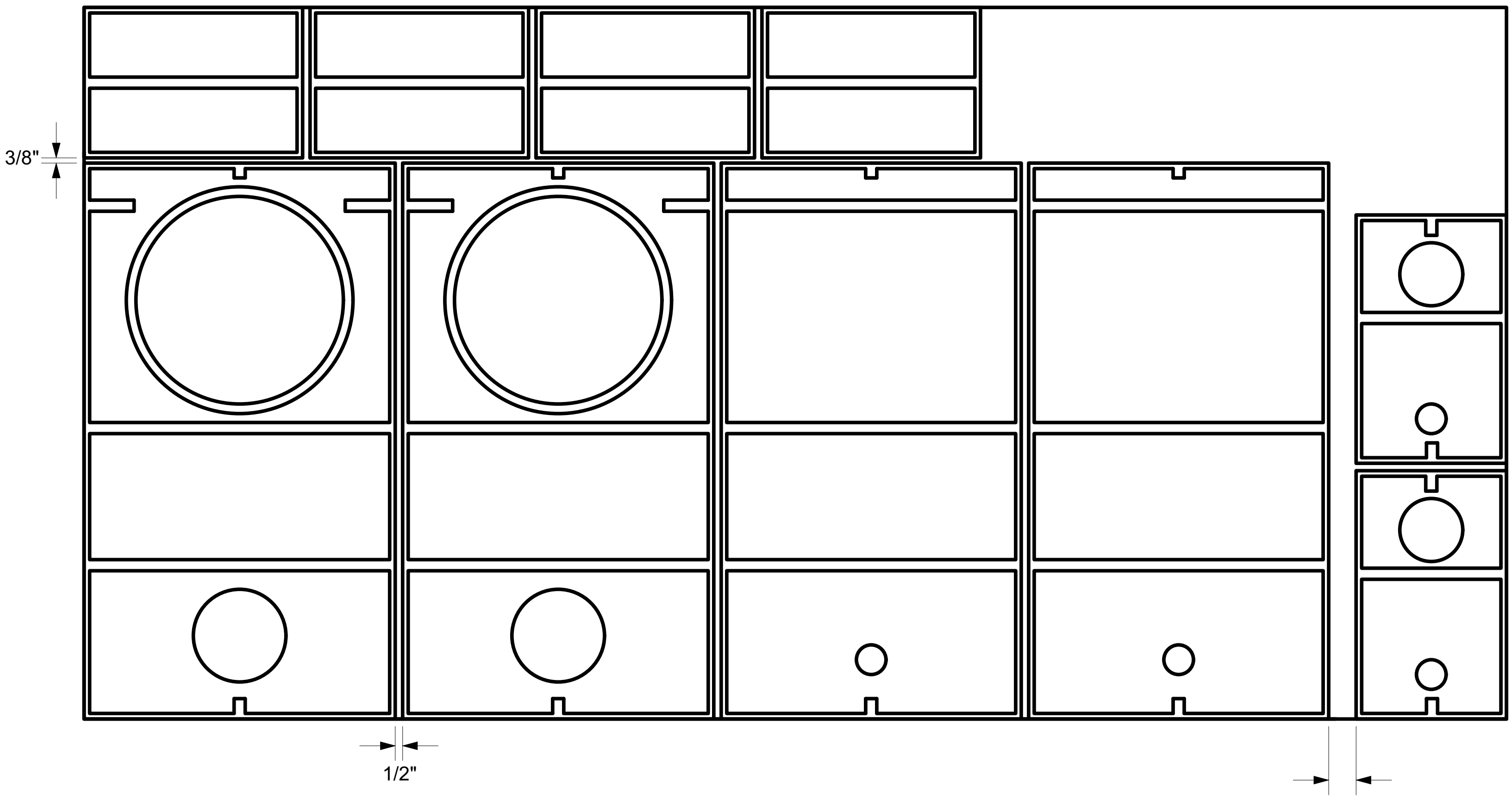
Subwoofer - Supports

1-1/2" = 1'

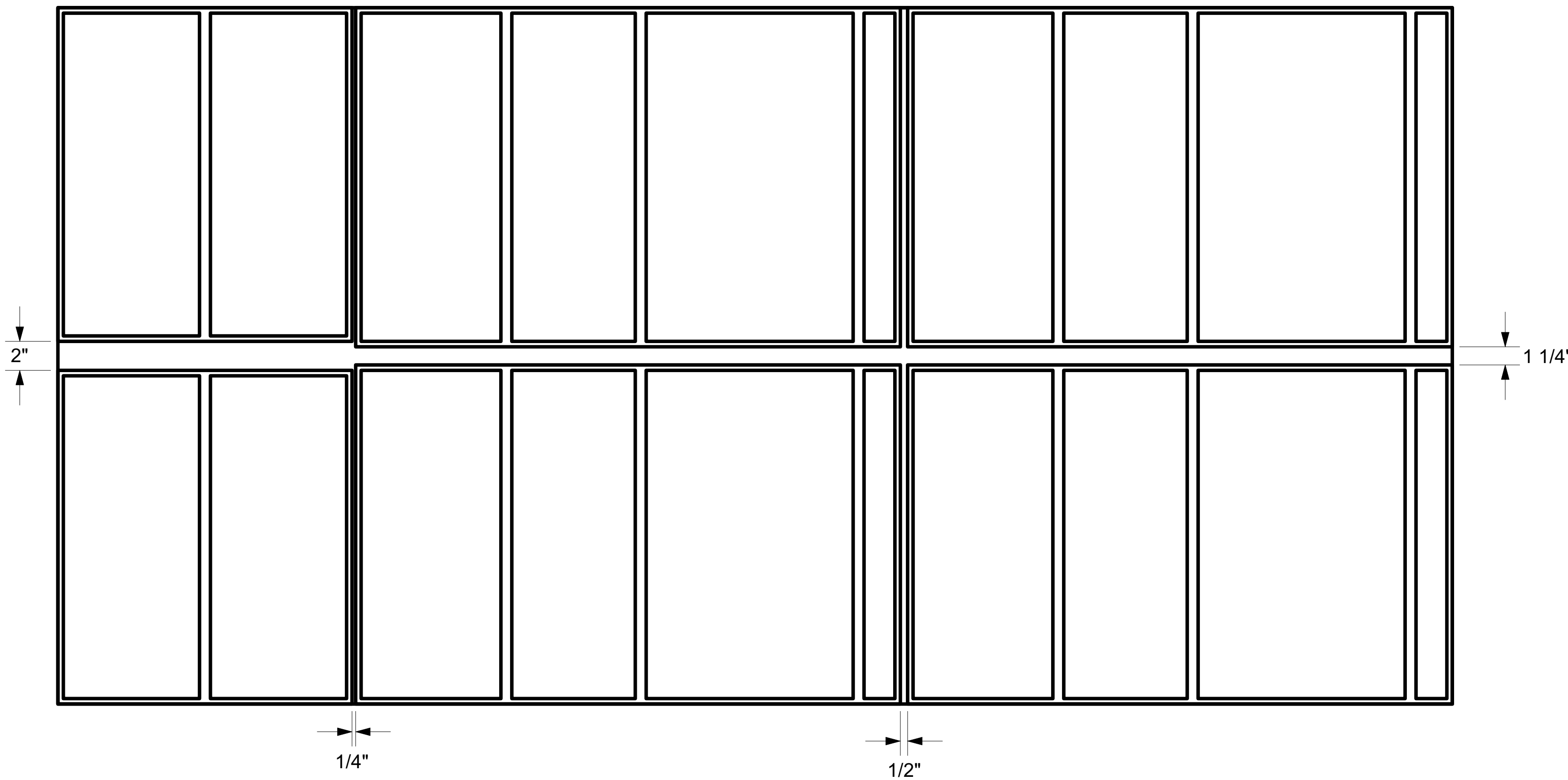
One Printer Page

Plate 12

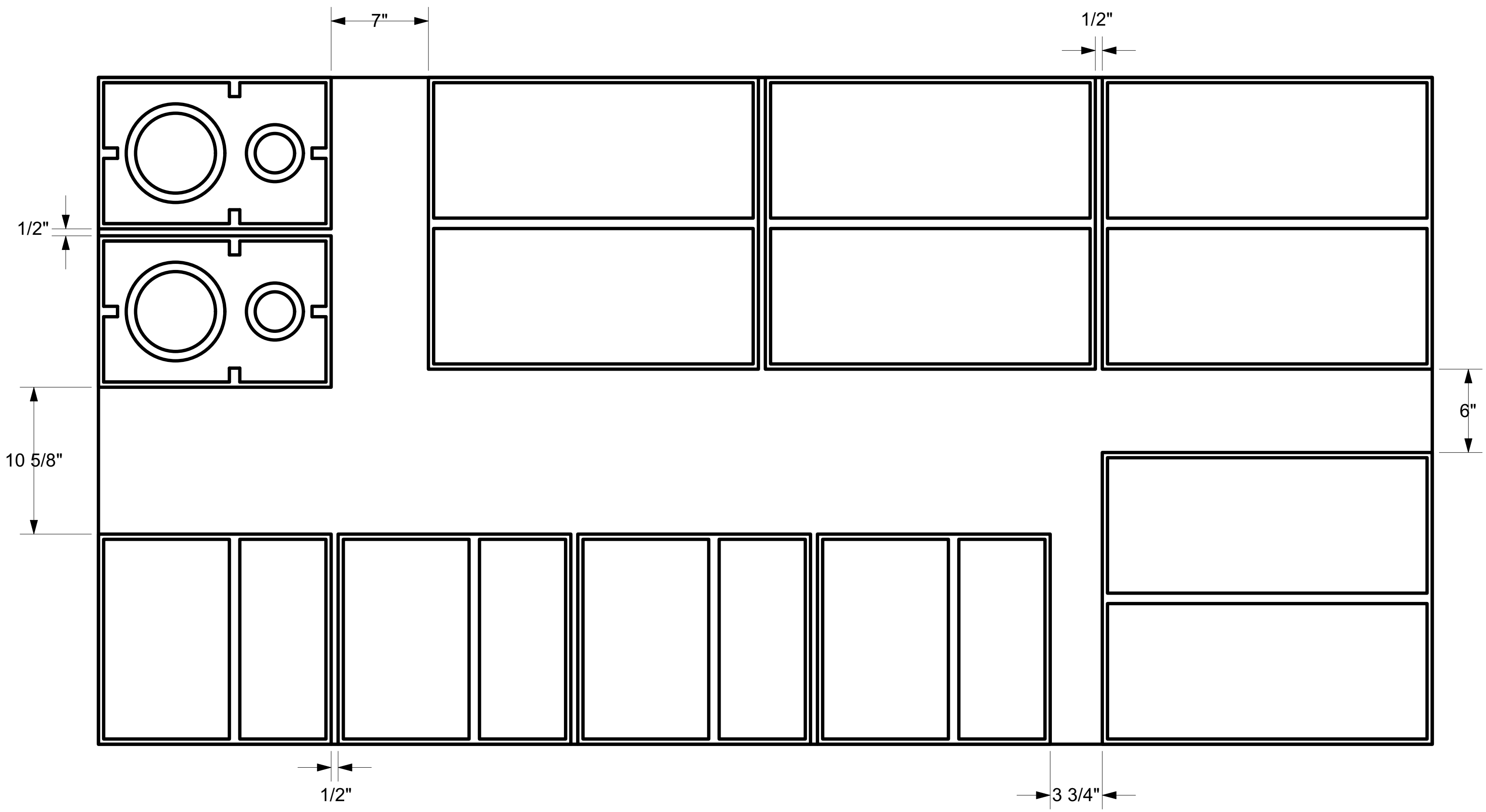
Vectorworks Educational Version



Vectorworks Educational Version



Vectorworks Educational Version


7"
1/2"
1/2"
6"
10 5/8"
1/2"
3 3/4"

Project or show title here

Producing Entity

Revision #: / Revision Date:	
1	02/15/23
1	02/15/23
1	02/15/23
1	02/15/23
1	02/15/23

Venue

Designer Name

Draftsperson Name

Drawing Type

Scale

Client Name

Supervisor Name

Drawing Print Size

Plate #

Vectorworks Educational Version