FA4740 - TRANSDUCER THEORY

Home Audio System *Documentation*

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Functional Description

I am creating a home television stereo system to supplement an entertainment center, primarily for watching movies and video games. Referencing other documentation on loudspeaker construction, it would appear this follows a listening back approach to design. This means that the speakers will be used to replicate recorded sounds and present previous recordings as they are, as opposed to creating new sounds[1]. I would like the loudspeakers to survive long distances of travel, as I will need them to survive moving to a new home, as I relocate to my new job, and likely another move to a house within another five years. This means that they will not need to be moved frequently, but durable enough that they may survive being shook up over transit. The goal will be to develop a system for high personal enjoyment, with minimal concern for hi-fidelity and mixing needs. An SPL output high enough for listening in an average living room, with a nice consistent frequency response (with bass not being super critical). Achieving these goals will require a construction that can attempt to simulate a home theater sound system on a lower budget, ideally under $450, with plans for future updates allowing for a supplemented surround sound system.

Using as a stereo home theater setup, these speakers will likely be placed in a room with minimal acoustic reverberations (due to the general clutter of a living room), but will need to have a sufficient sound pressure level output to reach the opposite end of the room. Additionally as multiple listeners may be present in the living room in different locations, a good off-axis response is desired so the listeners may all have similar listening experiences. The current concept is for a floor standing, stereo pair of cabinets. These loudspeakers must be durable enough to allow for easy human and vehicle transportation. With the anticipated quieter nature of the setting, protective additions such as grills are not anticipated.

These speakers should not only sound good, but also look appealing to the eye. With this in mind I am considering using finished maple as the front baffle for both speakers, with the remainder of the boxes made up of painted MDF. With portability in mind, somewhat discreet handles on the rear of both loudspeakers would be an excellent addition, along with a weight that allowed for a single person to comfortably carry one loudspeaker on their own. This weight will go hand-in-hand with the size of these loudspeakers, which are intended to be approximately 2 feet tall, as this size would fit easily within a vehicle and not be too cumbersome for a single person to carry.

To properly illustrate the focus of the design, the pie chart system created by John Murphy is used[2]. This visual will help to illustrate the priorities laid out in this functional description.

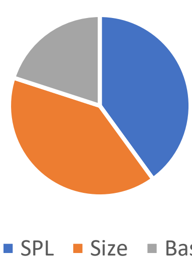

Figure 1: System Priorities

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

[2] Murphy, John L. *Introduction to Loudspeaker Design.* Page 56

Technical Specification

Loudness

Standards

To avoid hearing damage with the use of my loudspeaker, I will be considering the acceptable noise dose I am willing to be exposed to from my speakers. When looking at NIOSH's recommended exposure limit, it is important to consider what is a safe listening level to prevent hearing damage. For my purposes of a home theater, I will be considering an average use cycle of approximately 2 hours. According to NIOSH an exposure to 88-dBA for 2 hours would equal about half of one's daily does.[3] With this being a worse-case scenario, I believe my speakers must be able to achieve levels up to this limit, but will not be performing regularly at these levels.

When considering the primary use for the speakers, I must try to follow guidelines for the ideal movie listening experience. Looking at THX reference level, movies are often mixed with around +20dB SPL of headroom, as opposed to a headroom of +12dB SPL used in heavily compressed music. Listening levels should be adjusted accordingly, as dialogue levels for movies is around 83 dB when used in a movie theater. However, this level is 78 dB when in small rooms, such as a living room. Therefore, this level will be the more critical level to note. Considering the use will be in a small room, and my listening habits often skew to quieter levels, it will not present a major issue if these peaks are not reached from the maximum listening levels. Therefore, the listening level may be dropped when using the loudspeakers to account for the peak headroom that may be present, considering a +12 dB SPL for music listening and +20 dB SPL for movie listening.[4]

Personal Preferences

Performing the relevant tests on my listening habits, I was able to determine some sound pressure level estimates for what is desired from the constructed loudspeakers. Looking at the figure below, we see a trend of listening habits over the course of a day (it should be noted that these levels focus more on listening to music). The earlier parts of the day are primarily focused on headphones/earbuds, with the evening being the primary time for loudspeaker usage. From these results of SPL output, we can see that the loudspeakers must be able to reach levels up to 85 dBA on average, with peak levels measured on the SPL meter reaching up to 90 dBA[5]. This would correlate with the anticipated levels addressed in OSHAs safe listening practices.

[3] Franks, John R, Mark R Stephenson, and Carol J Merry. "Preventing Occupational Hearing Loss – a Practical Guide." – Page 90

[4] Acoustic Frontiers. 2013. THX Reference Level Explained.

[5] Jacobson, Matthew. *Lab #1 SPL Lab*.

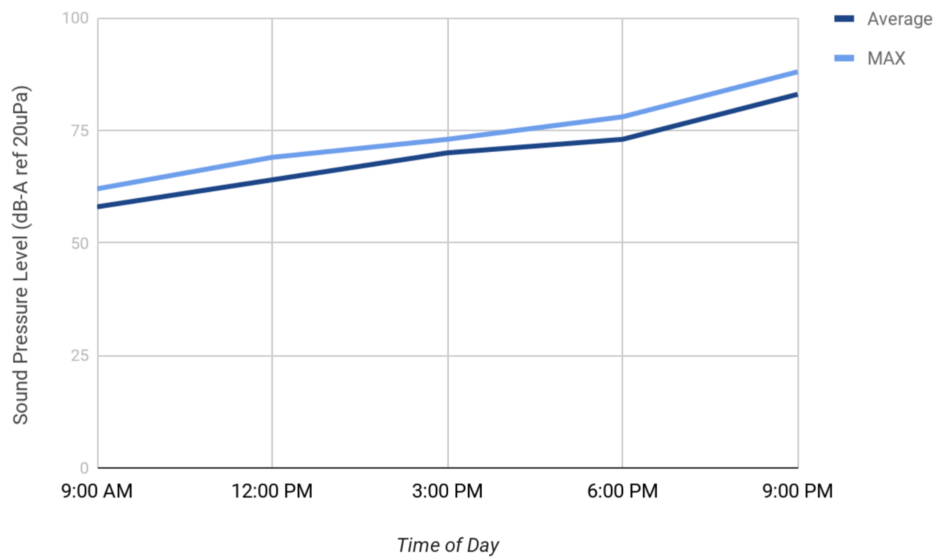


Figure 2: SPL Listening Levels over 12 Hours[4]

Listening at a Distance

To understand the peak levels the loudspeaker will likely be outputting, I have developed the chart seen in figure 3 to visualize what peaks can be experienced when using the above value of 90-dB as a maximum listening level. The K20 peak should be the main focus to consider for movies (see previous *Standards* section). However, since the speakers will be listened to at a distance, the listening level is adjusted for the SPL output that the loudspeakers must have to give the listeners 90-dB at the 3-m distance. The calculation for this output is:

(90dB) + 10 x log_10(3m) = 94.8 dB

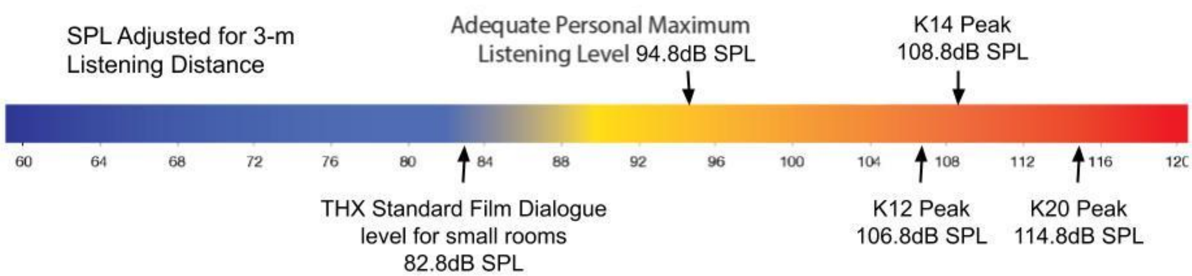


Figure 3: K-System SPL Output[6]

Amplification Requirements

Understanding the requirements needed to power my loudspeakers, I have used some estimates to perform preliminary calculations. Most drivers have a sensitivity around 85 dB SPL w/ 1 watt of power at a distance of 1 meter, or better. Being used in a living room space as a home theater, an estimate for distance from the loudspeakers is estimated at approximately 3 meters. The speaker will then be estimated to produce approximately 88 & 90 dB due to the

[6] Plummer, Christopher. *Transducer Theory Lecture*.

standards and preferences described above. Therefore, the calculations for the speaker amplification would be:

dBW = L_required – L_sensitivity + log_10(D_listener/D_reference) + HR [7]

W = 10 ^ (dBW / 10)

(90dB) – (85dB) + 20 x log_10(3m/1m) = 14.54 dBW

10 ^ (17.54dBW / 10) = 28.46 W

(87dB*) – (85dB) + 20 x log_10(3m/1m) = **11.54** dBW

10 ^ (11.54dBW / 10) = **14.26 W**

*****Calculated for stereo by subtracting 3 dB from 90dB

Looking at the above calculations it would seem that if the maximum levels were considered, an amplifier of over 50W would be necessary to power the speaker, however considering the loudspeakers will be played in stereo, it would appear that a 50W amplifier would be sufficient to power each individual cabinet, due to the required power reaching approximately 28.5W.

Final Numbers

To summarize, the above sections have made sure to highlight the SPL output expectations and the amplification requirements of the loudspeakers. NIOSH notes the dangers of listening to volumes for prolonged periods that exceed the daily noise dose. With this in mind, the speakers will not want exceed 88 dBA for prolonged periods over 2 hours. This should not pose a problem, as my listening records show my maximum listening SPL reached over the course of a day never exceeded 90 dB, with averages remaining in the mid 80's at the loudest period towards the end of the day. When considering movie watching being the primary use case for the loudspeakers, a headroom of +20 dB for peak levels should be given. To achieve these levels described, the speakers must have an amplifier able to output up to 28.5 W to the system (assuming both speakers are running and the listener is 3 m away). With this in mind, I selected two Fosi Audio 50W amplifiers[8] to use to power each cabinet.

[7] Crown Audio. 2020. System Design Tools.

[8] Texas Instruments. 2017. "TPA3116D2 15-W, 30-W, 50-W Filter-Free Class-D Stereo Amplifier Family With AM Avoidance."

Frequency Response

Bandwidth

To understand the desired limits of the loudspeakers bandwidth, a frequency roll-off experiment was performed with multiple different songs across various genres. These tracks will help to give an idea of how much low end is needed to be output by the subs in the loudspeakers being created. The figures below demonstrate the limits to what the speaker can neglect within the low end of the frequency response of the drivers. To cover the range of roll-offs that may occur within the bandwidth, the test was performed with a 1st order curve and a 3rd order curve. Looking at the reference tracks used, I also saw that Bruno Mars' track, 24K Magic, was able to reach the lowest frequencies of the tracks, reaching down to 30 Hz. With these as a reference, it would appear that considering a 1st order roll-off the drivers must be able to reach frequencies of at least 100 Hz, but preferably 75 Hz (if the budget allows for the preferred option). Considering a 3rd order roll-off it would appear that 80 Hz would be an acceptable limit to the bandwidth, with a preferred reach of around 50 Hz.

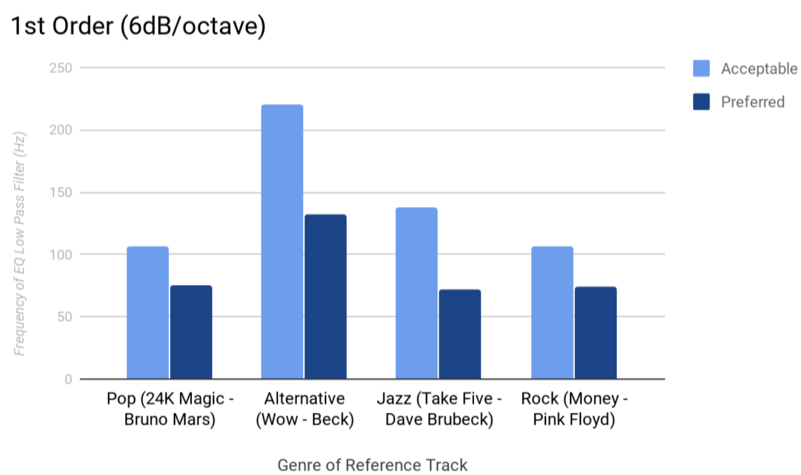


Figure 4: 1st Order Low Pass Filter Listening Results[9]

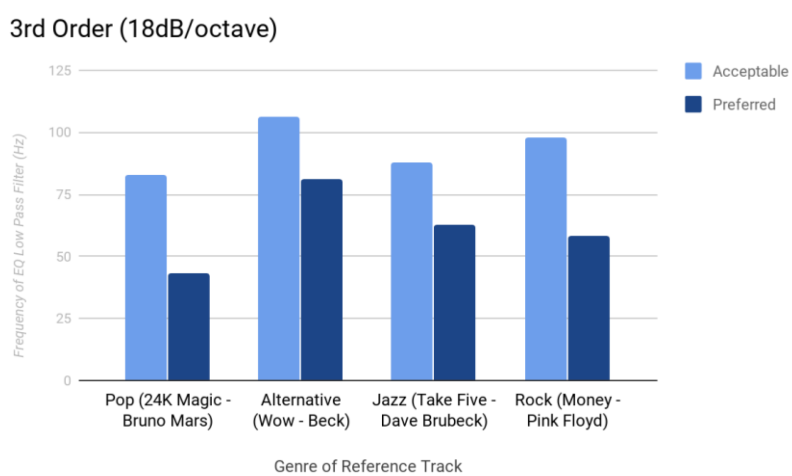


Figure 5: 3rd Order Low Pass Filter Listening Results[5]

[9] Jacobson, Matthew. *Lab #1 SPL Lab*.

Voicing

To develop the desired sound system for watching movies, one must consider some specific attributes that must be present within the frequency response curve. To create a system that achieves a clean low end with minimal distortion, but also has an even and clear high end, two types of curves could be created. The first being adding a slight bump to the low-end frequencies with the cross-over allowing for a consistent flat response for the mid to high frequencies. This would allow for the clean, powerful, booming sound I would like to have from my speaker. The second, and more likely frequency response that will attempt to be created from the loudspeaker output would be a flat response from the low to mid frequency range, with a slight, gradual decrease occurring in the higher frequencies. This will allow for the low end of the speakers to appear louder and clearer in comparison. To achieve either of these options, I have been considering implementing an active cross-over into my design to allow for easier adjustment of the frequency response curve to achieve the desired output.

Cabinet Details

Low Frequency Resonance

To properly account for any resonances that may occur within the enclosure, tests were performed on a variety of genres to gain an understanding of the frequencies that might be reached. Using the iZotope plug-in I was able to determine the lowest frequencies achieved from a variety of tracks. Going over the test it appeared the lowest frequency reached was 30 Hz, the source being a pop song by Bruno Mars called 24K Magic. With my listening preferences often skewing towards a desire for low end, which is prevalent in this track, I believe it would be a good goal to develop my cabinet with a resonance below 50 Hz if possible, though it should be noted that my goal of a low budget may cause limit the low end slightly. Using a vented speaker design should make it easier to achieve the desired low end, accuracy, and sound output, while also reducing the size of the cabinet.

Internal Reflections

Due to the somewhat rectangular shape planned for my loudspeakers, it will be important to utilize sufficient insulation in the back of my cabinet to account for the internal reflections that will occur within the loudspeaker. These reflections will also be reduced from the shape of the cabinet, as the front baffle is planned to be at 30 degree angle from normal. With the back of the vented cabinet remaining perpendicular, the misalignment of these faces will allow for the reduction of some of the internal reflections anticipated.

Edge Diffraction

To attempt to reduce the presence of edge diffraction of the loudspeakers, the shape of the front of the loudspeakers must be adjusted. To truly eliminate edge diffractions a perfect sphere would be used as a shape, but this would be unrealistic with my current construction constraints. Therefore, to adapt to this the front baffle of the loudspeaker will have a smoothed finish to the edges surrounding the tweeter[10]. The tweeters and drivers will also be

[10] Apollonio, Paul. *Identifiying Legitimately High Fidelity Loudspeakers: The Cabinet Face & Stuffing*.

flush mounted to the front, without a grill, to allow for a smooth front surface baffle. These adjustments will reduce the presence of these diffractions.

Mounting/Location

The desired placement of the loudspeakers will be on the floor, next to my future television/entertainment system to be used as a home theater setup. As the type of floor for the speakers is not yet decided, rubber feet may be a good addition to isolate the loudspeaker from the floor. Additionally, as the speakers may be placed near a wall, to be near a television system, the ports for the speakers would be most effective on the front or side of the loudspeakers, facing away from the wall.

Desired Dispersion

Considering the use case of the loudspeakers being designed for a smaller room, such as an apartment living room, the space can be considered small. Therefore, the speaker will need to output sound at least 3-meters away from the cabinets, if not further. With multiple listeners present in the room as well that desire similar listening experiences, it would be ideal to have quality off-axis dispersion.

Size & Weight

To develop a better understanding of the cabinet size, I used WinSpeakerz software to estimate the size of my cabinet using some drivers I had in mind as references. When sizing the speakers, I have tried to predict their place within the furniture orientation my future living room will have. Therefore keeping their height below a meter will allow for the cabinets to not block the television when compared to most entertainment systems I have encountered. Below I have included an estimate for my cabinet size using multiple drivers as reference.

Estimated Dimensions (H x W x D): **18” x 10” x 15”**

I am willing to increase size of my loudspeakers, but I would like to keep within a height of 2 feet tall. From this information, it should be noted that my desired weight for each these speakers is about **20-30 lbs.**, with a maximum weight not to exceed **40 lbs**. This is so it is not too difficult to carry the speakers, but is not crucial, as I am valuing sound output and low-end over size and weight due to the fact they will not be moved significantly after they are put in their place.

Visual Aesthetics

Keeping with many of the attributes described above, the loudspeaker is planned to be approximately a 2 feet tall floor standing pair of speakers. The front baffle of the cabinet will be made of finished maple, with the drivers made flush with the front face, as well as the ports placed at the lower half of the front face. The edges of the front baffle will be rounded around the upper half of the baffle, surrounding the tweeter. The whole front baffle will be at approximately a 30-degree angle, with the back face being perpendicular to the ground. The surrounding sides will be made of MDF and will be painted black.

Driver Selection

Woofer

With the goal being to create a two way system at a lower price range, I made my focus for woofers within a size of 8" and below $75 dollars. Below is a comparison between a few of the woofers I focused my search on. The table shows a variety of important characteristics while the graph presents a visual for comparison of the woofer prices (with dot sizes), peak thermal SPL (on x-axis), and the ideal extended shelf vented F3 of each woofer found on WinSpeakers (identical parameters were used, see page 15 for detail). See appendix for further detail on the manufacture specifications for the discussed woofers.

Table 1: Woofer Overview

	Price	Cone	Sensitivity	F3	Max Power
Dayton Audio RS225-8"	$58.98	Aluminum	86.8 dB 2.83V/1m	28 Hz	160 W
Visaton W200S-4 8"	$46.98	Treated Paper	86 dB 1W/1m	40 Hz	115 W
HiVi M8N 8"	$34.86	Aluminum / Magnesium	86 dB 2.83V/1m	28 Hz	160 W

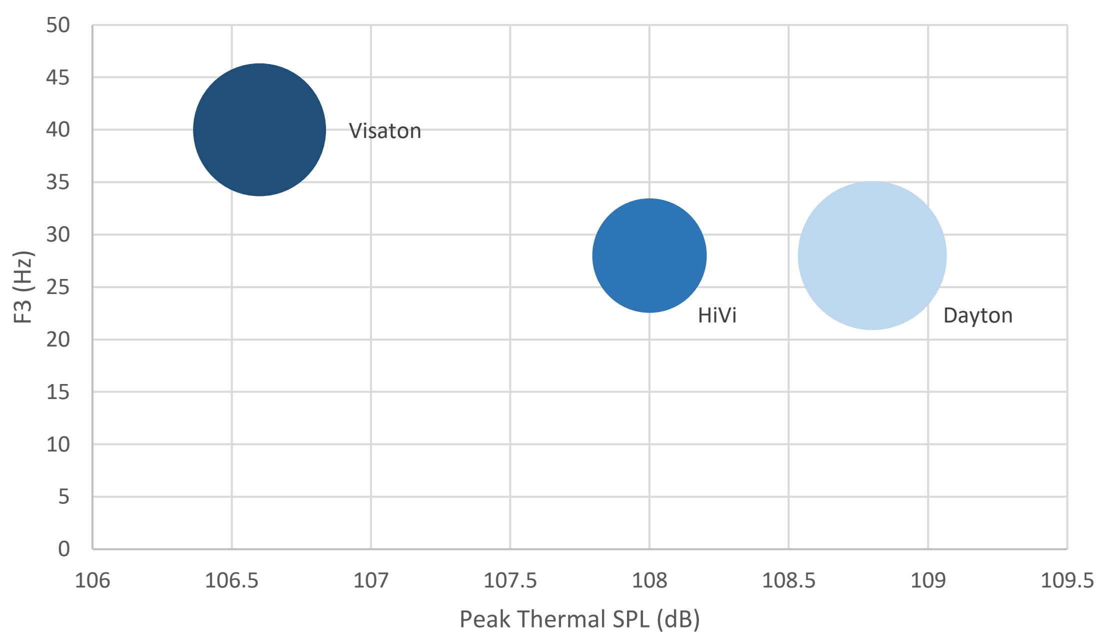


Figure 6: Woofer F3/SPL Comparison

Woofer 1 Detail

Dayton Audio RS225-8 8” Aluminum Reference Woofer[11]

Overview

- Highest cost
- Clear crossover point
- Less reach in low end
- Higher SPL output

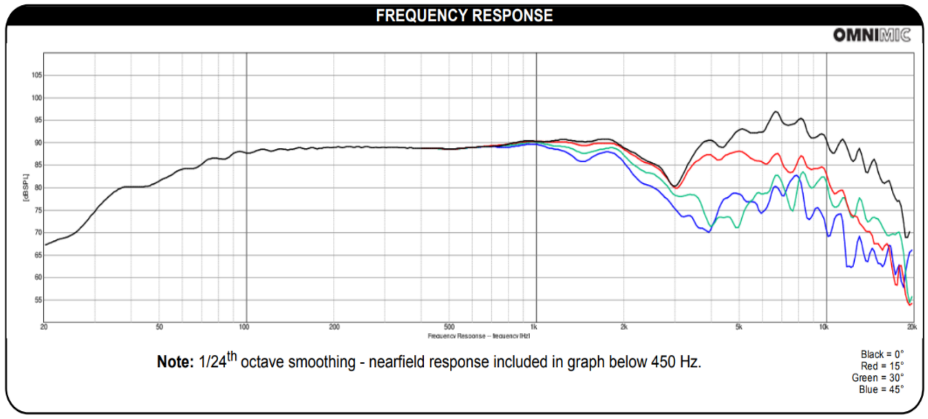


Figure 7: Manufacture Frequency Response

Requirements

Cost: $58.98
Size: 8”
Breakup starts at: 3k Hz
Breakup amplitude peak: +8dB@6.75k Hz
Recommended crossover: Below 3k Hz
Thermal Power Handling: 160-W at 108.8dB SPL
Low Frequency: 50Hz sealed, 28Hz vented

Figure 8: Advertised Image of Dayton Woofer

Driver Review

The Dayton Audio Reference Series RS225-8 is an excellent woofer for the price, an impressive bass-response woofer for the price. The driver has the capability to be an excellent half of a two-way system, with a reasonable crossover point with excellent wide dispersion. The F3 for this woofer reaches back to 28-Hz when used in an extended shelf, therefore it will be able to reach 30-Hz, my preferred 1^{st} and 3^{rd} order roll-off frequency (when ported). Given the target SPL of 90-dB (w/ Amplifier headroom of 3-dB) at a distance of 9 feet, the driver requires 20-Watts of power. Using identical parameters, an Amplifier supplying the calculated 28.5-W would be able to output an SPL of 92-dB, meeting the listed listening demands. With budget being a high priority with my build, this woofer would make an excellent addition to the system.

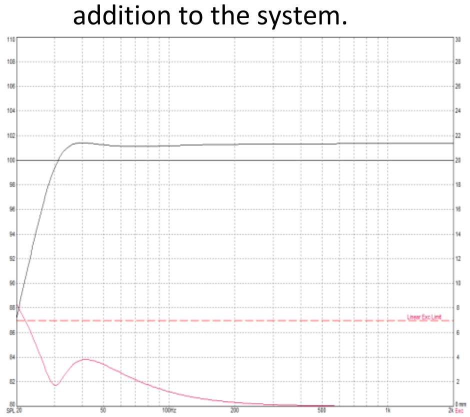


Figure 11: Frequency Response of Bass Boosted System

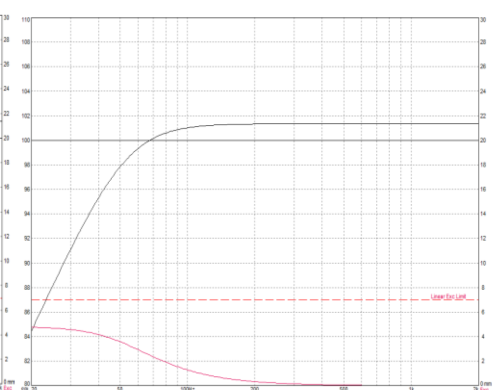


Figure 9: Frequency Response of Sealed System

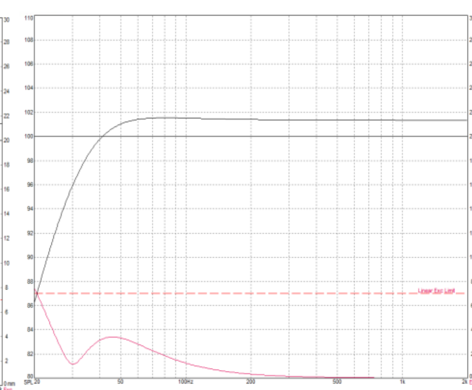


Figure 10: Frequency Response of Ported System

[11] Dayton Audio. 2020. "Dayton Audio Rs225-8 8" Reference Woofer." Parts Express.

Woofer 2 Detail

Visaton W200S-4 8” Woofer with Treated Paper Cone 4 Ohm[12]

Overview

- Dispersion unclear
- Low distortion
- Lower power / less SPL output
- Good low end for cost
- Paper cone material less durable

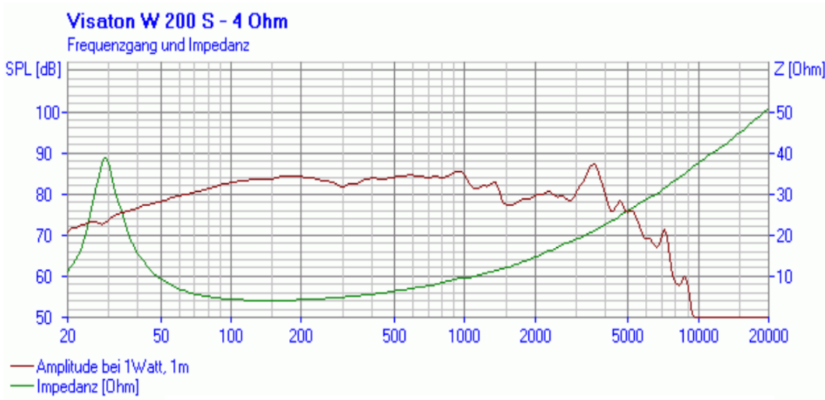


Figure 12: Manufacture Frequency Response & Impedance

Requirements

Cost: $46.98
Size: 8”
Breakup starts at: Approximately 3k Hz
Breakup amplitude peak: +4dB@3.5k Hz
Recommended crossover: Below 3k Hz
Thermal Power Handling: 115-W at 106.6dB SPL
Low Frequency: 60Hz sealed, 40Hz vented

Figure 13: Advertised Image of Visaton Woofer

Driver Review

The 9029 W200S-4 8” Visaton Woofer is a great woofer for the price, with low distortion and high resolution. The driver has the capability to supplement the two-way system in mind, though the dispersion may come into question (as the manufacturing specifications vary with visualization. The thing to note would be the more lacking bass reach (the lowest of the three), with an F3 of 40-Hz when ported and bass boosted. This would be within the frequencies needed for the home theater usage of the speaker, though would not reach my most ideal limits. The excursion for this speaker is also quite dramatic and may present issues of distortion in the low end. Given the target SPL of 90-dB (w/ Amplifier headroom of 3-dB) at a distance of 9 feet, the driver requires 24-Watts of power. Using identical parameters, an Amplifier of suppling 28.5-W would be able to output an SPL of 91-dB, meeting the listed listening demands. Though the value is quite nice, the distortion and lack of presence in the lower frequencies may present an issue with the sound desired from the system.

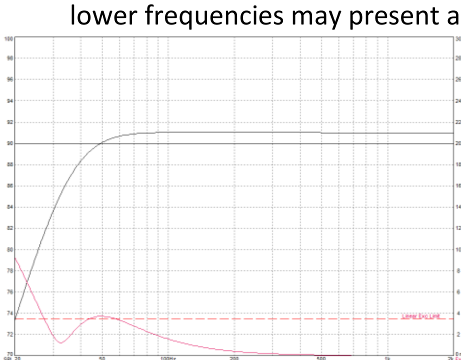


Figure 14: Frequency Response of Ported System

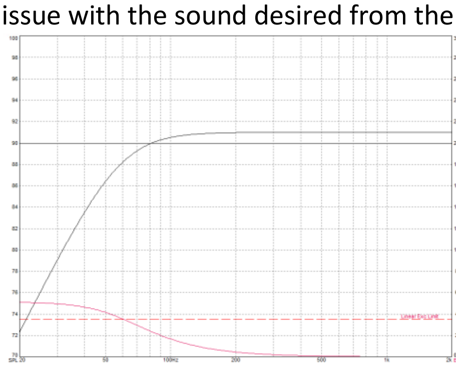


Figure 15: Frequency Response of Sealed System

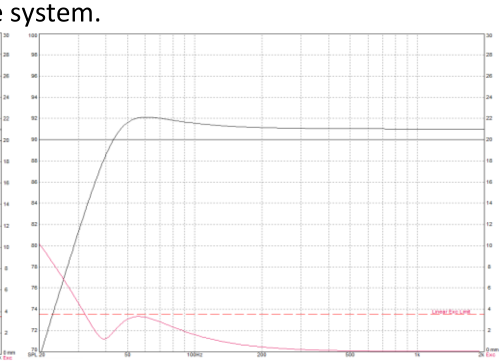


Figure 16: Frequency Response of Bass Boosted Shelf

[12] Visaton. 2020. "Visaton W200S-4 8" Woofer with Treated Paper Cone 4 Ohm."

Woofer 3 Detail

HiVi M8N 8” Aluminum / Magnesium Woofer[13]

Figure 17: Advertised Image of HiVi Woofer

Overview

- Lowest costing woofer
- Visually appealing with bright gold/orange hue
- Rough spike in higher frequencies
- Higher excursion, could lead to higher distortion

Requirements

Cost: $34.86
Size: 8”
Breakup starts at: After 2k Hz
Breakup amplitude peak: +10dB@2.25k Hz
Recommended crossover: Below 2k Hz
Thermal Power Handling: 160-W at 108dB SPL
Low Frequency: 48Hz sealed, 28Hz vented

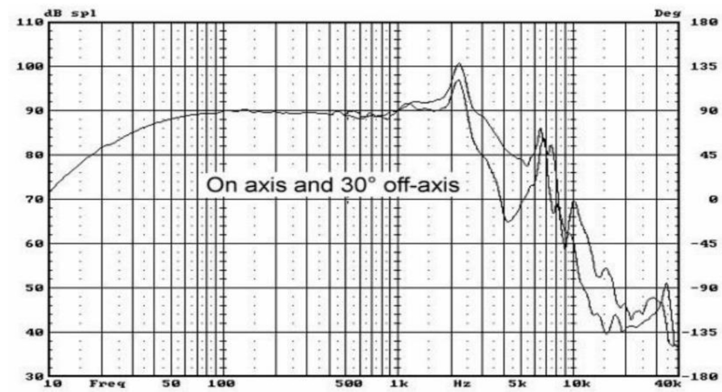


Figure 18: Manufacturing Frequency Response & Impedance

Driver Review

The HiVi M8N 8” Aluminum / Magnesium Woofer is an aesthetically pleasing woofer with a low price. This driver was explored due to the more interesting visual make-up that may appear nice on the face of a maple cabinet. The driver has the capability to supplement the two-way system in mind, though the off axis response may come into question (as the manufacturing specifications vary with visualization). The driver is capable of reaching the desired low frequencies when ported, with an F3 of up to 28-Hz when ported, matching the Dayton woofer. This would be well within the frequencies needed for the home theater usage of the speaker. Given the target SPL of 90-dB (w/ Amplifier headroom of 3-dB) at a distance of 9 feet, the driver would exceed this output with the recommended 28.5-W achieving an average SPL of 91-dB. However the break-up peak for this speaker is quite dramatic and may present issues with the crossover region trying to create a flat response.

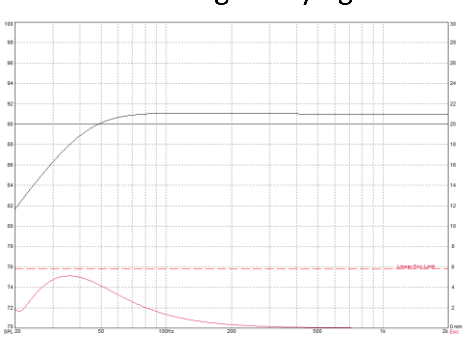


Figure 20: Frequency Response of Ported System

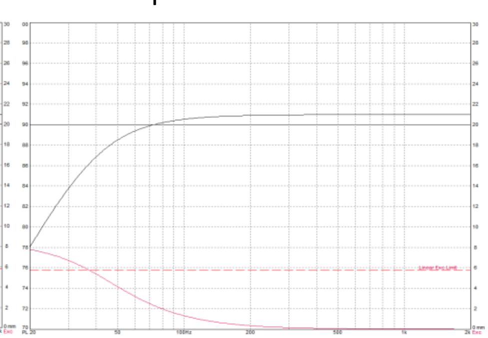


Figure 21: Frequency Response of Sealed System

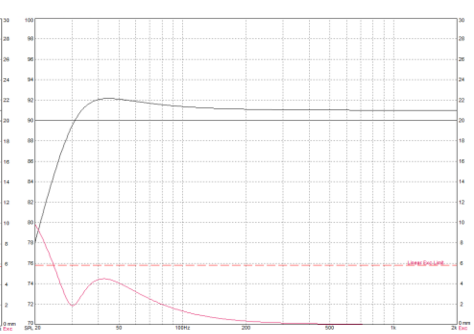
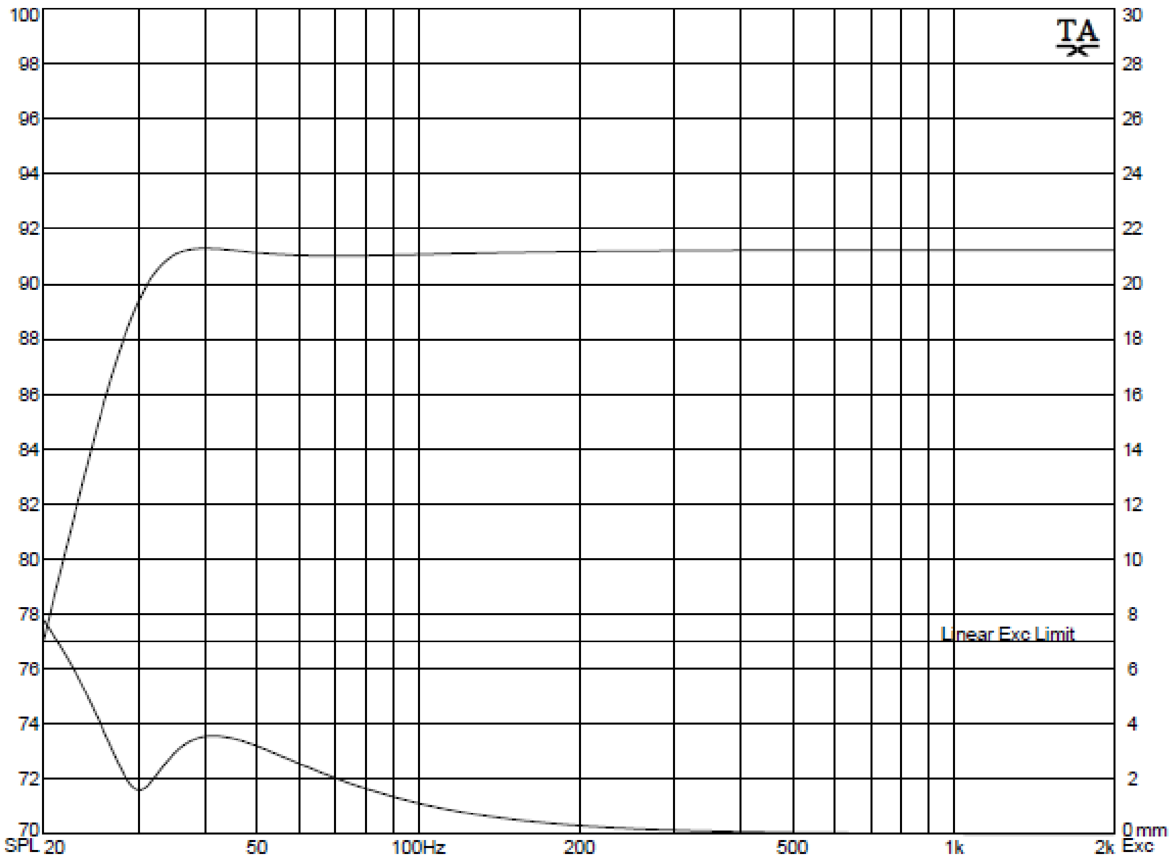


Figure 19: Frequency Response of Bass Boosted System

[13] Hi-Vi. 2020. "HiVi M8N 8" Aluminum / Magnesium Woofer." Parts Express.

Chosen Woofer

Going over the options discussed above, I am moving forward with the Dayton Audio RS225-8 8" Reference Woofer. This is due to its low distortion for the cost, flat response, and the low F3 achieved when ported and bass boosted. The frequency response plot of the driver within defined system parameters (25-W input power, at 9-ft distance, and 2 cubic feet cabinet) with a vented, bass-boosted plot can be seen below. Calculated using WinSpeakerz software.



Driver Parameters

Driver:

Nominal Diameter	D =	8	in
Nominal Power	P =	0	Watts
Sensitivity (1W/1m)	SPL =	86.8	dB SPL
Free Air Resonance	f(s) =	28.3	Hz
Total Q	Q(ts) =	0.38	
Electrical Q	Q(es) =	0.51	
Mechanical Q	Q(ms) =	1.46	
Equivalent Volume	V(as) =	2	cu ft
Nominal Impedance	Z =	0	Ohms
DC Resistance	R(e) =	6.5	Ohms
Max Thermal Power	P(t) =	160	Watts
Max Linear Excursion	X(max) =	7	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.

Box Parameters

System Type: 4th Order Vented Box

Box Volume	V(B) =	2	cu ft
Closed Box Q	Q(tc) =	0.5374	
Box Frequency	F(B) =	30	Hz
Min Rec Vent Area	S(vMin) =	5.57	sq in
Vent Surface Area	S(v) =	6.283	sq in
Vent Length	L(v) =	7.379	in
Compliance Ratio	alpha =	1	
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 =	3	m

Tweeter

With the goal being to create a two way system at a lower price range, I made my focus on dome tweeters below $75 dollars. Below is a comparison between a few of the tweeters I focused my search on. See appendix for further detail on the manufacture specifications for the discussed tweeters.

Table 2: Tweeter Overview

	Price	Dome	Sensitivity	Beam Width Narrowing Point	Max Power
SB Acoustics SB29SDAC-C000-4 29mm	$46.20	Textile	93 dB 2.83V/1m	15 kHz	60 W
Dayton Audio RS28A-4 1-1/8" Reference Series	$37.98	Aluminum	92.5 dB 1W/1m	15 kHz	80 W
SEAS Prestige 29TFF/W (H1318)	$54.50	Fabric	92 dB 2.83V/1m	6 kHz	90 W

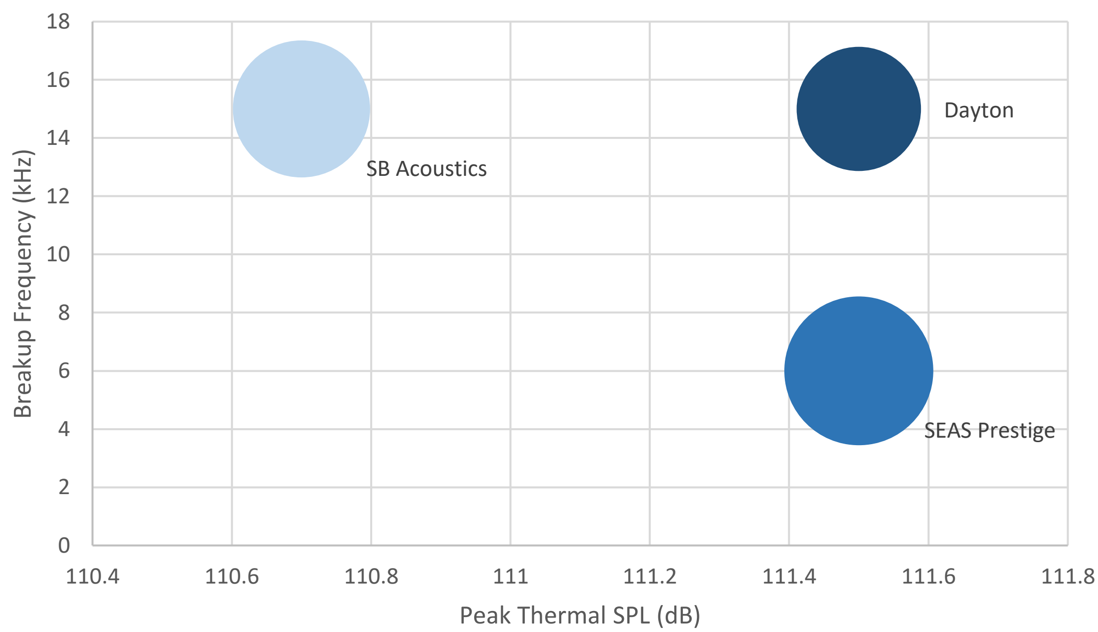


Figure 22: Tweeter Breakup/SPL Comparison

Tweeter 1 Detail

SB Acoustics SB29SDAC-C000-4 29mm Textile Dome Tweeter[14]

Overview

- Flat Response
- High breakup point
- Clear black look
- Low distortion

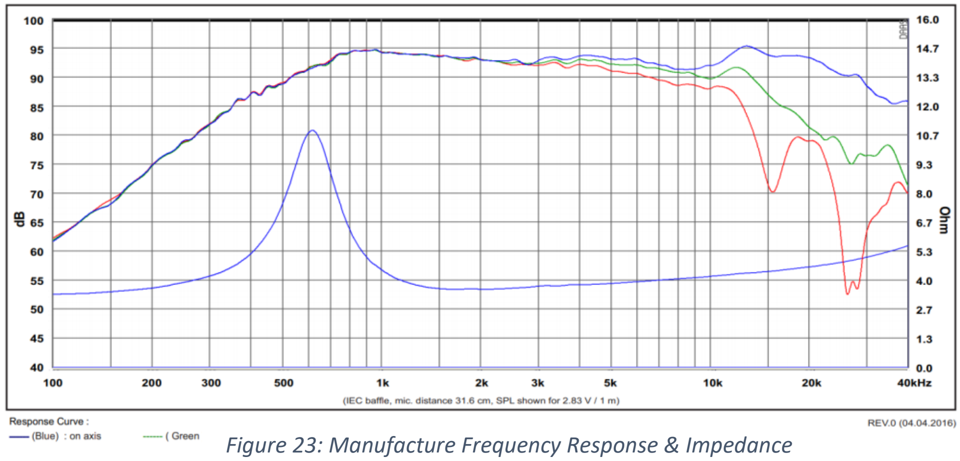


Figure 23: Manufacture Frequency Response & Impedance

Requirements

Cost: $46.20
Size: 4" – 29mm Dome Diameter
Sensitivity: 93-dB (2.83-V / 1-m)
Breakup starts at: 15k Hz
Breakup amplitude peak: +3dB@13k Hz
Recommended crossover: Below 1k Hz
Thermal Power handling: 60W at 110.7dB SPL

Driver Review

This tweeter was found through Zaph Audio – "Tweeter Mishmash", as this list of tested and reviewed drivers brought me to a current model of this well-received tweeter. The SB Acoustics SB29SDAC-C000-4 textile dome tweeter is a quality tweeter for a lower cost, with smooth response and low distortion. The dispersion is also very nice compared to other tweeters, with off axis dispersion separating at 15k Hz. The SPL output of this tweeter will also easily exceed the needs I have, only needing to reach around 88-dB, but able to exceed well beyond 100-dB. Given the target SPL of 88-dB (w/ Amplifier headroom of 3-dB) at a distance of 9 feet, the tweeter only requires ~5-Watts of power. Using identical parameters, an Amplifier of 50-W would be able to output an SPL of 98-dB, exceeding the listed listening demands. The speaker looks rather simple with black disk appearance, and would be easy to countersink into the baffle, with a very simple appearance. This tweeter would match well with several 8" woofers to complete a nice two-way system.

[14] SB Acoustics. 2016. "SB29SDAC-C000-4." madisound.

Tweeter 2 Detail

Dayton Audio RS28A-4 1-1/8" Reference Series Aluminum Dome Tweeter with Truncated Faceplate[15]

Overview

- Lowest cost
- Flat response
- Cheaper appearance
- Mesh shield
- Low distortion

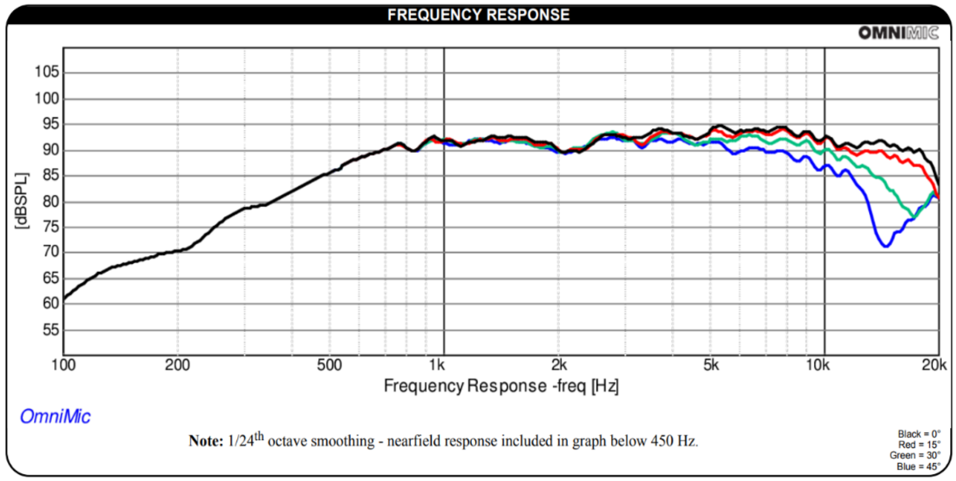


Figure 24: Manufacture Frequency Response

Requirements

Cost: $37.98
Size: 4.125" x 3.25" – 29mm Dome Diameter
Sensitivity: 92.5-dB (2.83-V / 1-m)
Breakup starts at: 15k Hz
Breakup amplitude peak: +0dB@15k Hz
Recommended crossover: Below 1k Hz
Thermal Power handling: 80W at 111.5dB SPL

Driver Review

The Dayton Audio Reference Series Aluminum Dome tweeter is a quality tweeter for a lower cost, with smooth response and low distortion. The dispersion is very nice compared to other tweeters, with off axis dispersion separating at 15k Hz. The SPL output of this tweeter will easily exceed the needs I have, only needing to reach around 88-dB, but able to exceed well beyond 110-dB. Given the target SPL of 88-dB (w/ Amplifier headroom of 3-dB) at a distance of 9 feet, the tweeter only requires ~5-Watts of power. Using identical parameters, an Amplifier of 50-W would be able to output an SPL of 98-dB, exceeding the listed listening demands. The soft cage in front of the tweeter creates a less than appealing look for a clean design, additionally the outer disk for this tweeter is a circle with cut off edges, which would require more precision to countersink into the baffle. Apart from the aesthetics, this tweeter would pair well with several 8" woofers to complete the desired two-way system.

[15] Dayton Audio. 2020. "Dayton Audio RST28A-4 1-1/8" Reference Series Aluminum Dome Tweeter with Truncated Faceplate." Parts Express.

Tweeter 3 Detail

SEAS Prestige 29TFF/W (H1318) Fabric Dome Tweeter[16]

Overview

- More dramatic dispersion
- Highest cost
- Visually appealing front plate
- Wave guide
- Lower crossover point

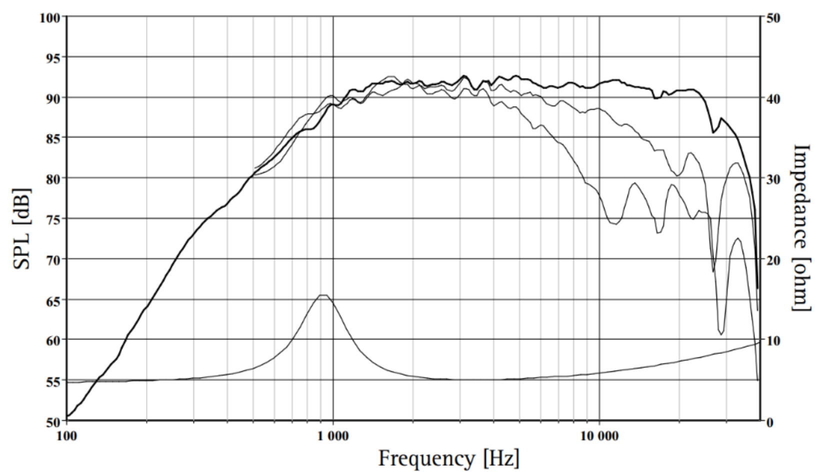


Figure 25: Manufacture Frequency Response & Impedance

Requirements

Cost: $54.50
Size: 4" – 26mm Dome Diameter
Sensitivity: 92-dB (2.83-V / 1-m)
Breakup starts at: 6k Hz
Breakup amplitude peak: +0dB@10.25k Hz
Recommended crossover: Below 2k Hz
Thermal Power handling: 90W at 111.5dB SPL

Driver Review

This tweeter was found through Zaph Audio – "Tweeter Mishmash", as this list of tested and reviewed drivers brought me to a current model of a well-received tweeter. The SEAS Prestige 29TFF/W Fabric Dome tweeter is a nice tweeter for a low cost, with smooth response and low distortion. The dispersion occurs earlier than others compared, with off axis dispersion separating at 6k Hz. The SPL output of this tweeter will also easily exceed the needs I have, only needing to reach around 88-dB, but able to exceed beyond 110-dB. Given the target SPL of 88-dB (w/ Amplifier headroom of 3-dB) at a distance of 9 feet, the tweeter only requires ~6-Watts of power. Using identical parameters, an Amplifier of 50-W would be able to output an SPL of 97-dB, exceeding the listed listening demands. The simple, but layered fabric design would look since on the front baffle, and would be an easier countersink with the simple circular design. Apart from the dispersion, this tweeter would pair well with several 8" woofers to complete the desired two-way system.

Chosen Tweeter

The SB acoustic seems to achieve the best overall results among the tweeters discussed. With its superior dispersion, simple design, and far reaching flat response, this tweeter would appear to be the best selection to make.

[16] SEAS Prestige. 2007. "SEAS Prestige 29TFF/W (H1318) Fabric Dome Tweeter." madisound.

Cabinet Design

Shape

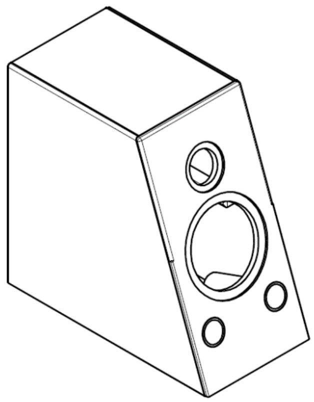


Figure 26: Cabinet CAD Model

Looking at Figure 23 to the left, the shape of the cabinet can be described as an extruded right trapezoid. This shape is used as the front baffle is angled at 70° from normal. This is done to angle the speakers up towards the ear height of the listener. The listener in question has been assumed to have an ear height of 3-ft or approximately 1-m, and will be sitting approximately 9-ft or approximately 3-m from the loudspeakers. The edges around the speaker have also been routed to reduce edge diffraction around the tweeter, and reduce edge sharpness around the top and front of the loudspeaker.

Materials

The two cabinets will be assembled with a total of 4 different types of lumber. The main source of wood for the cabinet will be a 4' x 8' sheet of Baltic Birch plywood ($80). This sheet will be used to make up the top, back, sides, and internal support of both cabinets. The front baffle will then be constructed with a layering of 3 types of hardwoods. The majority of the front baffle will be constructed from 6 board feet of Hard Maple ($24). To accentuate the light-colored maple wood, two different strips of darker colored woods will be used. A specialty strip of Red Heart wood ($18) and Padauk wood ($10).

Joints

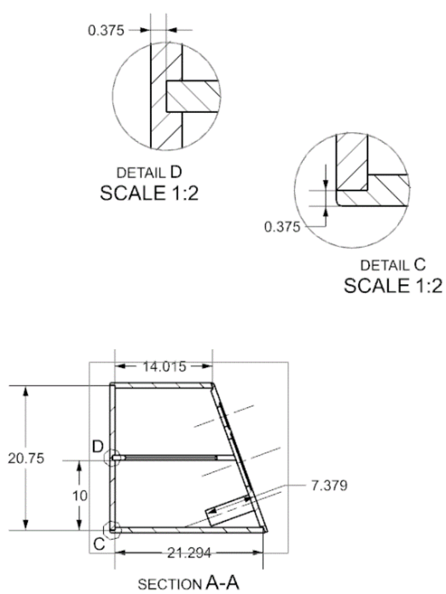


Figure 27: Joint Detail of Cabinet

To construct the cabinets, single rabbet joints will be used along the edges of the side panels, the back of the top and bottom panels, and along all the edges of the front baffle. An example of this joint can be seen in Figure 24, in Detail C, showing the single rabbet joint used on the back of the bottom panel. These will allow for a greater seal to glue the panels together. The other joint used in the design that can be seen in Figure 24 is a dado joint, which will be used along the center line, inset at .375", allowing for the cabinets to hold the internal support.

Bracing

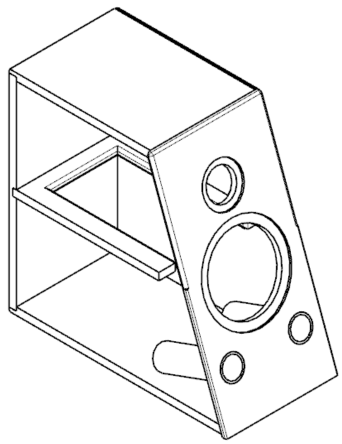


Figure 28: Internal Support Open View

To improve the structural integrity of the cabinets, a horizontal support will be placed along the centerline inside the cabinet as seen in Figure 25. The support will be extending out approximately 1.5” from the internal walls, leaving enough space to avoid contact with the front baffle and the back of the woofers. The internal edges of the structural support will also be routed to reduce internal reflections.

Drafting

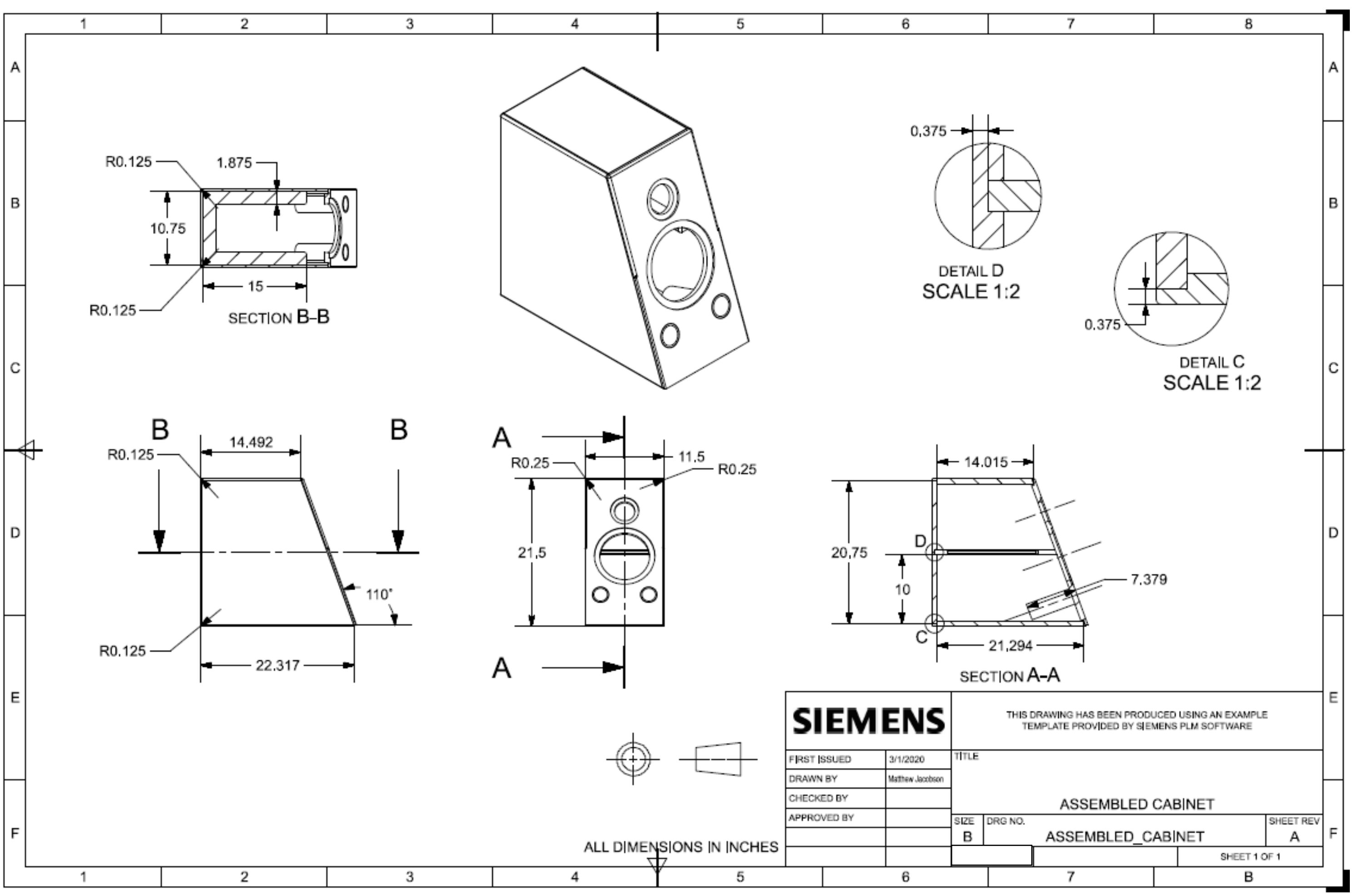


Figure 29: Assembled Cabinet Drawing

Figure 27 shows the dimensioned cabinet design included with the PVC ports set with the calculated tuning length of 7.379”. Figure 19 on the following page shows the dimensioned drawing of the most complex panel, the front baffle. 3-Dimensional models were created using Siemens NX software.

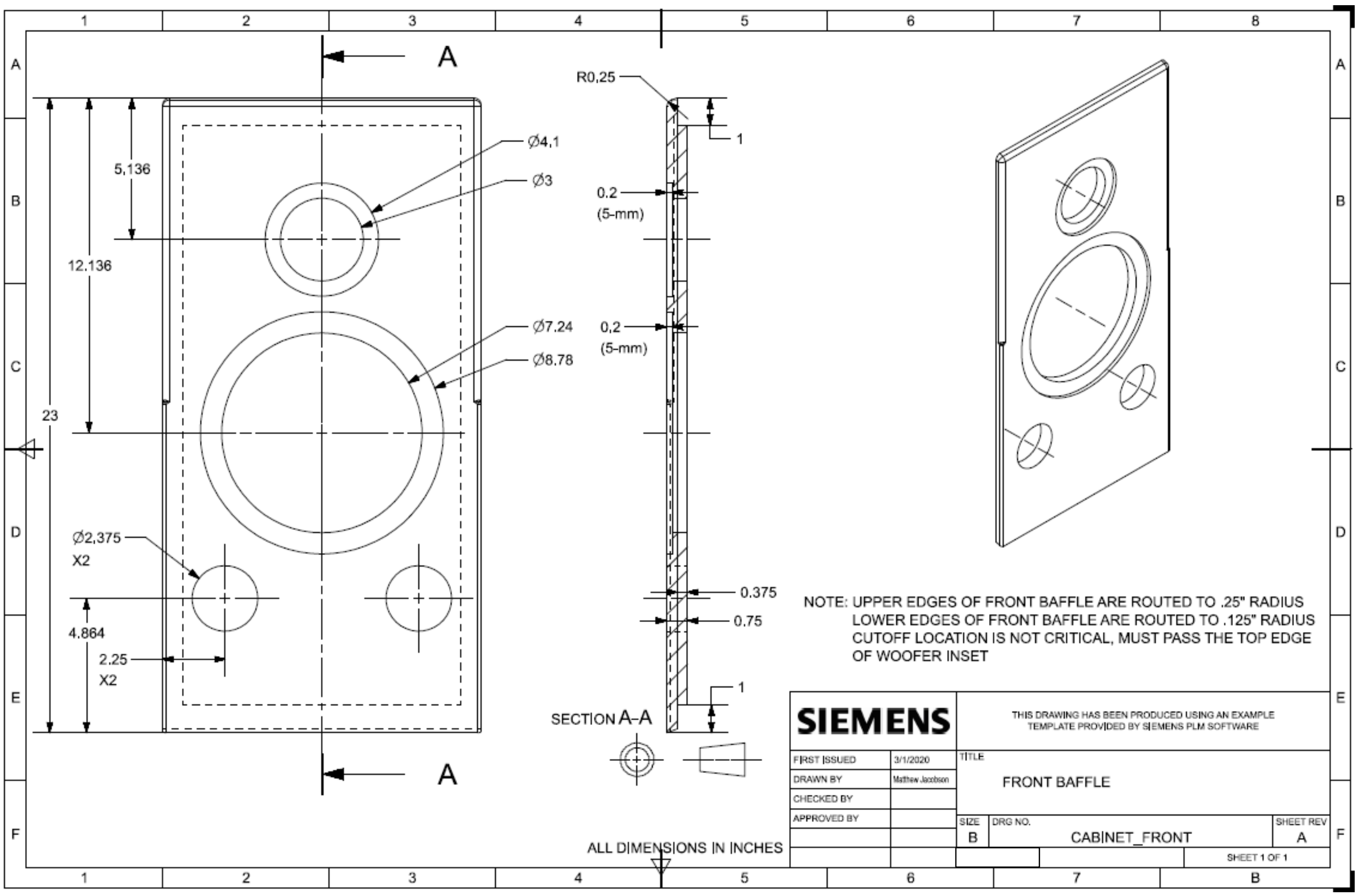


Figure 30: Front Baffle Drawing

Construction

First, when constructing the front baffle, the boards were glued together to create the stripes. Then a plainer was used to get the smooth even surface of the board. Next a Timesaver belt sander was used to get the precise thickness needed. Then a table saw was used to get the blank to the proper size. With the sizing defined, a CNC was used for cutting the holes for the tweeter and woofer. Finally, a table saw was used to get the finished size and angles needed to fit the angled parameters.

The sides were constructed using the table saw for getting the general size of the blanks. Then the CNC was used for getting the exact size. The boards were then finished off on the table saw to get the dado and rabbet joints.

The bottom, top, and back were completed similarly, with the table saw being used to cut to size and to make the dados and rabbet joints.

The final piece cut was the internal bracing, which was cut using the table saw for the overall dimensions, and then a rough cut for the internal circle curve was made using the band saw. A filleted edge was then added to the internal curve using a ¼" router.

Upon completion of all the individual boards, the box was assembled and glued together using wood glue and clamps. After the glue was wiped clean and was able to set, the slots for the triangular edge splines were cut into the cabinet using a jig configured to fit the table saw seen in Figure 28.

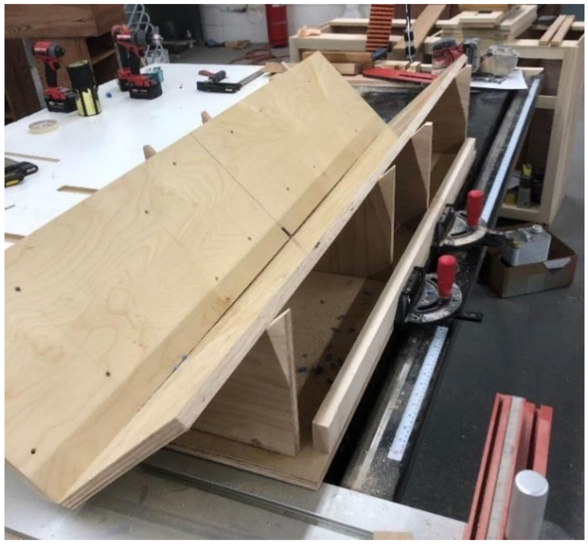


Figure 31: Table Saw Jig for Cabinet Edge Splines

The triangular splines were all cut incrementally using the table saw and glued into the slots of the cabinet with wood glue, with red heart used for the front baffle splines and maple used for the remaining edge splines (seen in Figure 29). Then after sanding the entire cabinets, the ¼" router was taken to all the edges of the cabinet (apart from the edges on the floor and the top of the front baffle which was sanded down). Once all the splines were inserted and the shape of the cabinets were complete, another round of sanding was done using a vibrating sander across the entire cabinet. Finishing that, all the sides of the cabinet apart from the front baffle were stained with Minwax red chestnut. After drying, the entire cabinet was then covered in a clear coating of polyurethane.

Figure 32: Edge Splines on Top of Cabinet & Front Baffle

With the cabinet finishing process complete, Minwax Blend-Fil Pencils were used on any scratches or small gaps seen on the cabinets. Other finishing touches included hand drilling a hole into the back of each cabinet (for the NL4 plug) using a 1” Forstner drill bit, and drilling additional screw holes for the four rubber feet placed on the bottom of each cabinet.

To create the ports, 2” inner diameter PVC pipe was cut with a miter saw to create two tubes of length 7.25”, with the final cuts performed incrementally to fit to the floor of the cabinet. An additional 30-degree angled cut was made using the miter saw to allow for the tubes to sit nicely while still achieving the needed diameter. With the cuts finished, the inside of the tubes was spray painted black. Caulk was then used to glue the tubes into place.

Internally, 2 pieces of insulation were glued to the back panel above and below the support brace, and surrounding the NL4 plug. Insulation was also added to the internal floor of the cabinets, leaving a few inches of space from the end of the PVC tube ports to allow for airflow. The remaining step with the cabinets themselves was to wire the drivers, connecting both the woofer and tweeter to the NL4 plug using crimp connectors. The final products of the cabinet construction can be seen below in Figure 30.

Figure 33: Finished & Internally Wired Cabinets

Crossover Design

When choosing between an active and passive crossover for my speaker system, I opted to go with the active crossover option. This was due to how easy it would be to adjust the system. With the active crossover, I will be able to easily adjust different parameters of my system digitally, allowing for any issues to be easily corrected without the need to purchase any additional components. With this in mind, I decided to purchase a MiniDSP 2x4 system[17] to work as my active crossover, as it had the amount of channels I needed for my stereo, two-way system.

When programing the DSP to achieve the desired frequency response, I referenced the desired frequency response curve described earlier in the report. The desired curve being a slight bump in the lower frequency, with a flat middle, and a slightly lowered higher frequency range. To achieve this, the two main things being considered will be the crossover point, and the baffle step of the cabinet.

The crossover point of the cabinet was the first thing to set up on the DSP. Looking at the manufacture frequency response of the selected woofer (see page 11, figure 7), the response curve remains relatively flat up to 1000 Hz. This point is also were the off-axis response begins to separate. Then looking over at the selected tweeter and the manufacture frequency response (see page 16, figure 20) the curve rises up and begins to flatten out at 1000 Hz. Considering these plots a crossover point at 1000 Hz was selected (see figure 31). When setting the crossover, a sharp 48dB/octave, Linkwitz Riley filter type was selected. This was to allow for a flat response at the crossover point. Additionally, a high pass filter was added at 25 Hz, to remove the danger of reaching the linear excursion limit referenced on page 14.

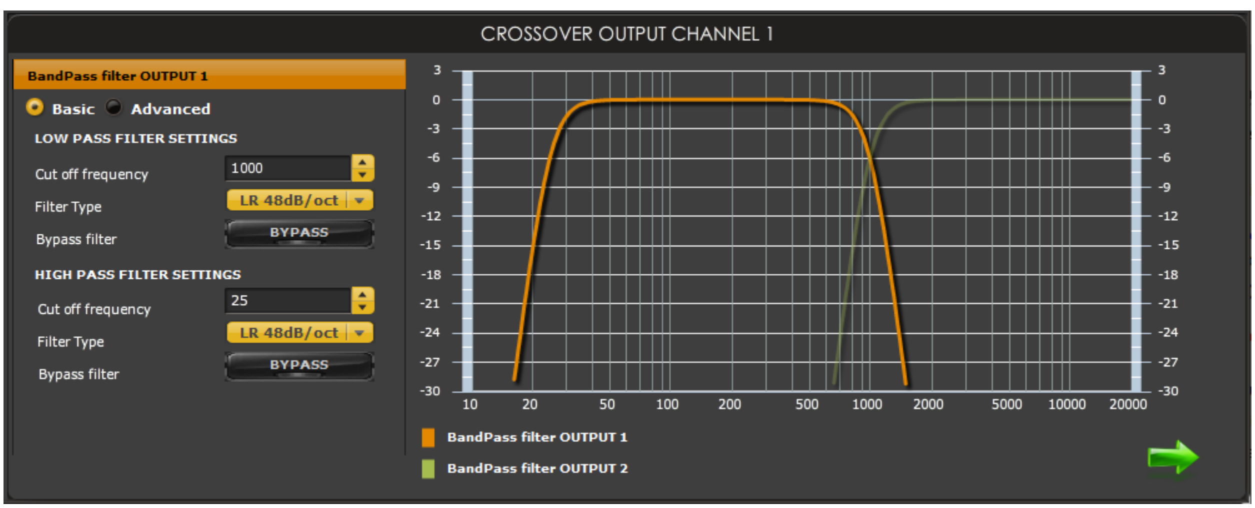


Figure 34: MiniDSP-2x4-Advanced Crossover Settings

The next issue to address on the active crossover was the baffle step. To find out what response could be expected with the constructed cabinets, the specifications of the chosen tweeter and woofer combination, and with the final dimensions of the front baffle were input into a baffle calculator. With the selected parameters, the calculator was able to output the frequency response of the baffle step which added to the original response curve.

[17] miniDSP. 2020. "miniDSP 2x4 Digital Signal Processor." Parts Express.

The resulting plot can be seen in figure 32. The plot shows an increased shelf peaking at approximately 1000 Hz at a level of 7.5 dB, with the shelf beginning to level out around 6 dB and drop down again within the higher frequency ranges beyond 20 kHz.

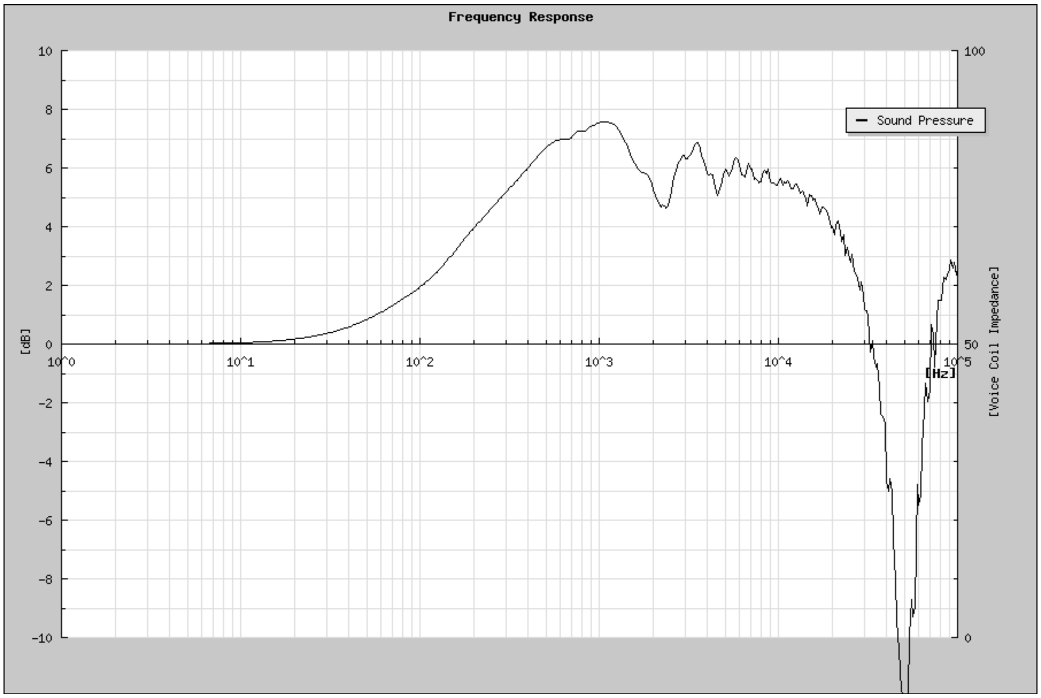


Figure 35: Loudspeaker Baffle Step Frequency Response[18]

To account for the results seen in the above frequency response, a parametric EQ was added to both the woofers and tweeters. Figure 33 shows the EQ set to the tweeters that accounts for the shelf with a gradual -6-dB high shelf starting at 1000-Hz. The peak at 1000 Hz was also adjusted with a -7.5 dB peak at the intended frequency. The final adjustment at 12,500 Hz with a small peak correction of -3 dB was done to correct a breakup frequency.

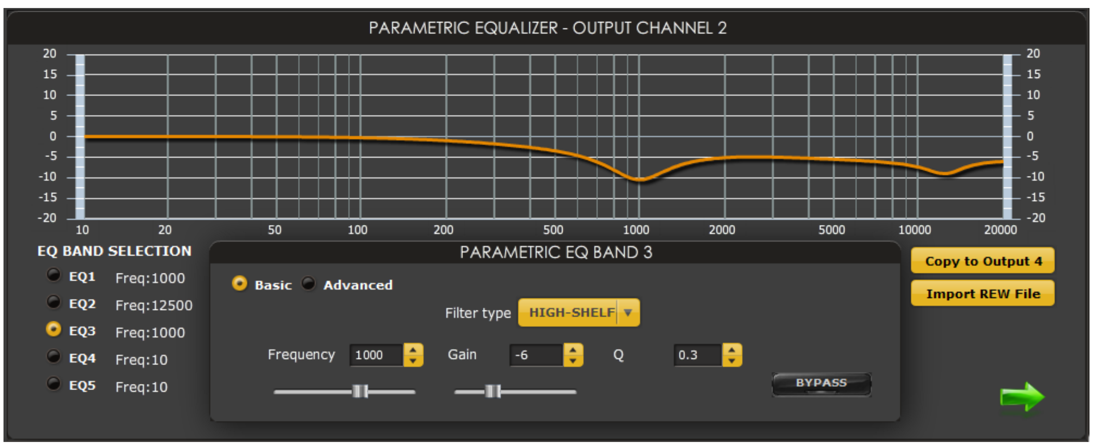


Figure 36: MiniDSP-2x4-Advanced Parametric Equalizer, Tweeter Channel

[18] Jurgen Micka. 2012. Online Baffle Step Calculation.

System Tuning

Note: This section was not able to be completed due to the closing of Michigan Tech's campus due to the COVID-19 epidemic. Future plans have been made to tune the completed loudspeaker cabinets upon a return trip to Michigan Tech in the latter half of Summer 2020 or early subsequent Fall.

Final Performance Documentation

Note: This section was not able to be completed due to the closing of Michigan Tech's campus due to the COVID-19 epidemic. Future plans have been made to tune the completed loudspeaker cabinets upon a return trip to Michigan Tech in the latter half of Summer 2020 or early the subsequent Fall. Upon completion of tuning the final cataloging of necessary data can be completed.

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Appendix

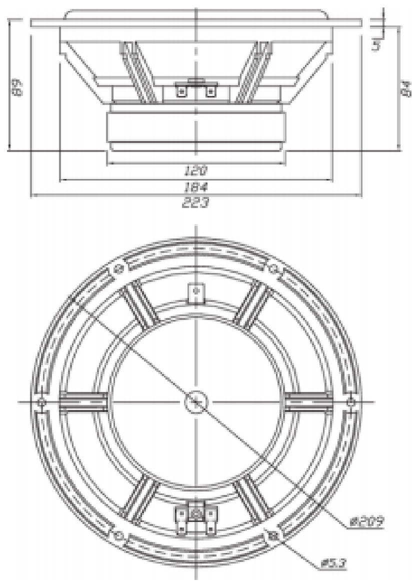
Manufacturing Specifications:

Dayton Audio RS225-8 8" Reference Woofer 8 Ohm Details

DAYTONAUDIO

RS225-8 8" Reference Woofer 8 Ohm

RS225-8



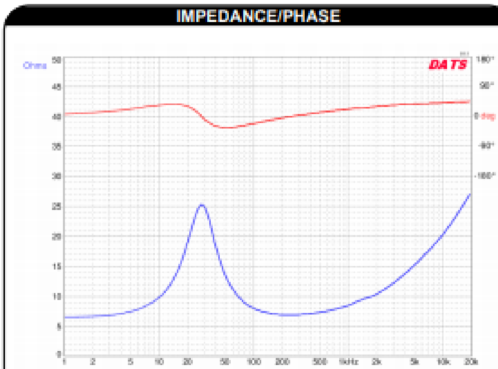
PARAMETERS

Impedance	8 ohms
Re	6.5 ohms
Le	0.86 mH @ 1 kHz
Fs	28.3 Hz
Qms	1.46
Qes	0.51
Qts	0.38
Mms	35.8g
Cms	0.88 mm/N
Sd	213.8 cm²
Vd	149.7 cm³
BL	9.05 Tm
Vas	56.8 liters
Xmax	7.0 mm
VC Diameter	38 mm
SPL	86.8 dB @ 2.83V/1m
RMS Power Handling	80 watts
Usable Frequency Range (Hz)	28 - 2,400 Hz

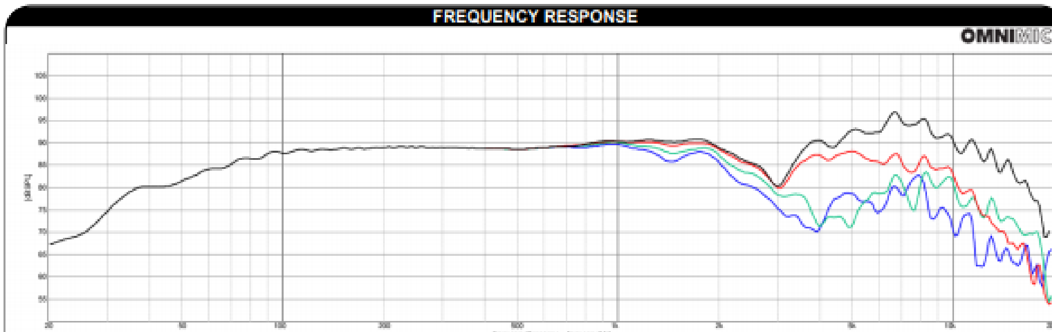
FEATURES

- One of the lowest distortion, highest resolution driver series available
- Low-distortion high-excursion motor system with two short-circuit paths
- Compliant suspension and rigid black anodized aluminum cone for strong bass performance
- Heavy-duty 6-hole cast frame, low-loss rubber surround, and solid aluminum phase plug
- Designed and engineered in the USA

IMPEDANCE/PHASE



FREQUENCY RESPONSE



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

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

Visaton W200s-4 8" Woofer with Treated Paper Cone 4 Ohm Details

Product Specifications

Nominal Diameter	8"
Power Handling (RMS)	75 Watts
Power Handling (max)	115 Watts
Impedance	4 ohms
Frequency Response	29 to 6,000 Hz
Sensitivity	86 dB 1W/1m
Voice Coil Diameter	1.375"

Thiele-Small Parameters

Resonant Frequency (Fs)	29 Hz
DC Resistance (Re)	3.4 ohms
Voice Coil Inductance (Le)	1.5 mH
Mechanical Q (Qms)	3.99
Electromagnetic Q (Qes)	0.38
Total Q (Qts)	0.35
Compliance Equivalent Volume (Vas)	2.3 $ft.^3$
Maximum Linear Excursion (Xmax)	3.5 mm

Materials of Construction

Cone Material	Treated Paper
Surround Material	Rubber

Mounting Information

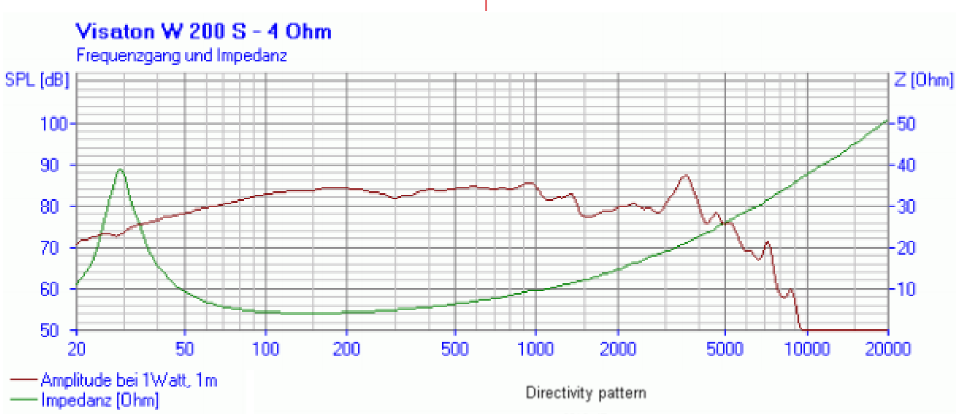
Overall Outside Diameter	9.13"
Baffle Cutout Diameter	7.25"
Depth	3.46"

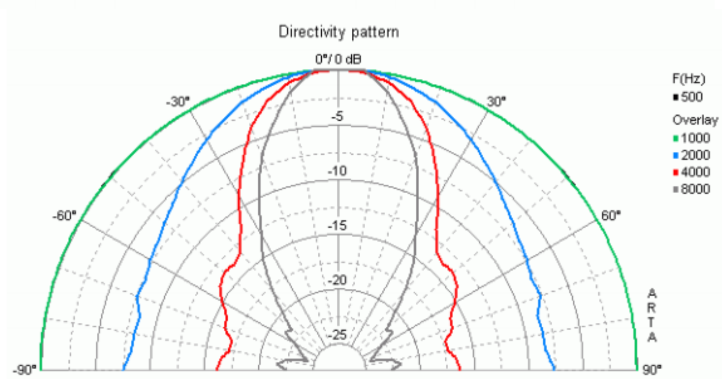
Optimum Cabinet Size (determined using BassBox 6 Pro High Fidelity suggestion)

Sealed Volume	0.51 $ft.^3$
Sealed F3	66 Hz
Vented Volume	1.13 $ft.^3$
Vented F3	39 Hz

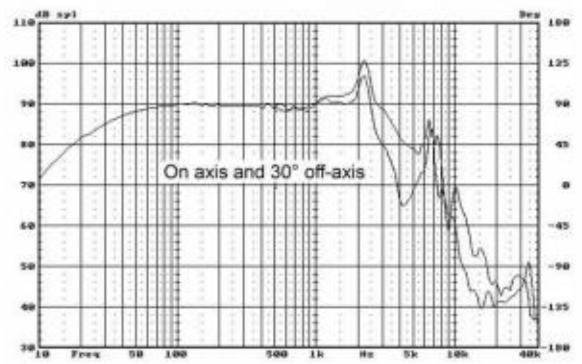
Visaton W200S-4 8" Woofer with Treated Paper Cone 4 Ohm

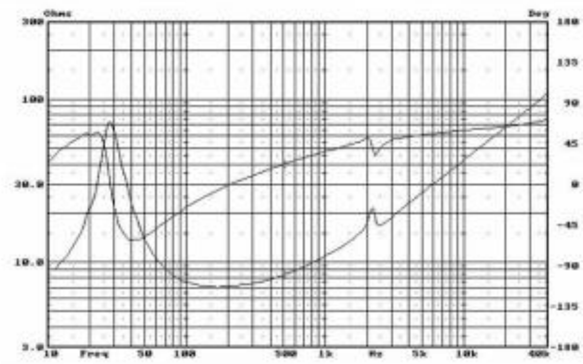
Brand	Visaton
Model	W200S - 4
Part Number	292-570
Product Category	Woofers
Unit of Measure	EA
Product Rating	★★★★★(2 Reviews)
Weight	3.624 lbs.
California Prop 65 ⚠	**WARNING:** Cancer and Reproductive Harm www.P65Warnings.ca.gov

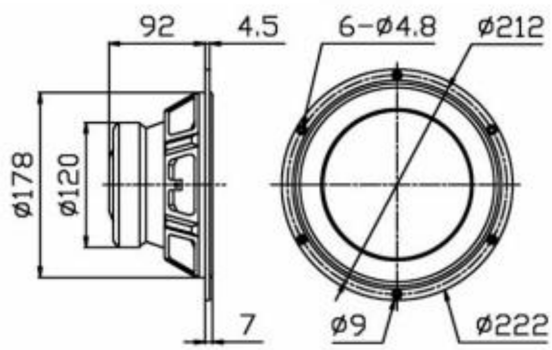




HiVi M8N 8” Aluminum / Magnesium Woofer Details





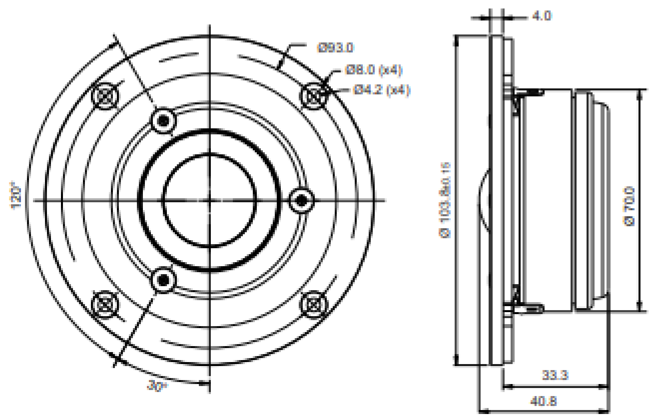


M8N SPECIFICATIONS

Nominal Impedance (Z)(Ω)	8
Resonance Frequency (Fs)(Hz)	29
Nominal Power Handling (Pnom)(W)	80
Sensitivity (2.83v/1m)(dB)	86
Weight (M)(Kg)	2.3
VC Diameter (mm)	35 SV
DC (Re)(Ω)	6.5
VC Length (H)(mm)	17.5
VC Former	Kapton
VC Layers	2
Magnet System	Outside Ferrite
Force Factor (BL)(TM)	9.6
Gap Height (He)(mm)	6.0
Linear Excursion (Xmax)(mm)	5.8
Suspension Compliance (Cms)(uM/N)	822
Mechanical Q (Qms)	5.02
Electrical Q (Qes)	0.50
Total Q (Qts)	0.45
Moving Mass (Mms)(g)	36.5
Effective Piston Area (Sd)(m^2)	0.0214
Equivalent Air Volume (Vas)(L)	53.5
Vented Box	Vb=22L,Fb=34Hz
	F-3=40Hz

SB ACOUSTICS

SB29SDAC-C000-4



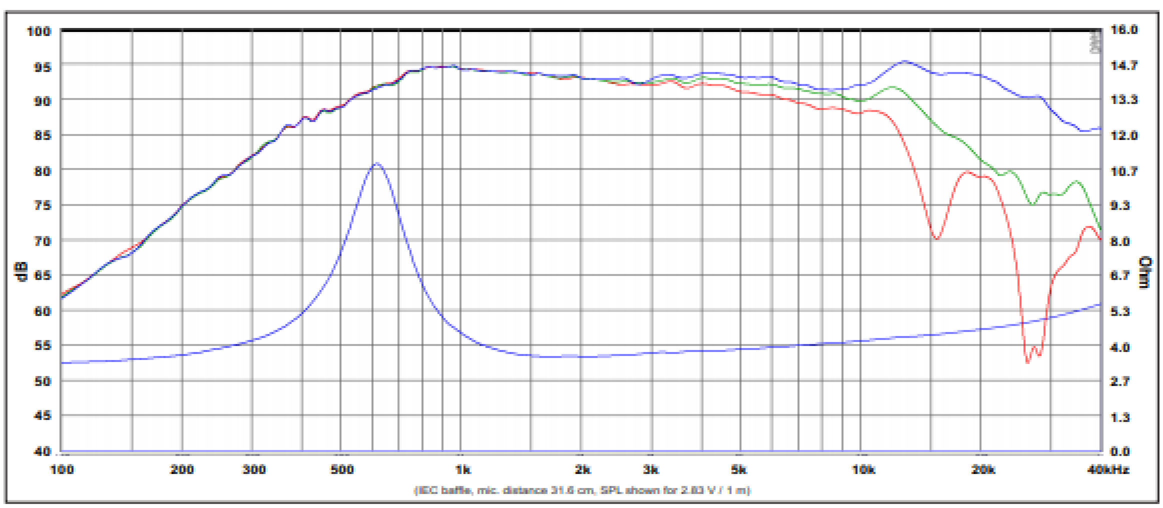
FEATURES

- Large surround dome for increased acoustic output.
- Dual balanced compression chamber for improved dynamics.
- Copper cap for reduced voice coil inductance and minimum phase shift.
- Saturation controlled motor system for low distortion.
- Non-reflective rear chamber with optimized damping for improved dynamics.
- Flow optimized vented pole piece for optimum coupling to rear chamber.
- CCAW voice coil for low moving mass.
- Long life silver lead wires.
- Low resonance frequency.
- Cast aluminium faceplate.

Specs :

Nominal Impedance	4 Ω	Free air resonance, Fs	600 Hz
DC resistance, Re	3.0 Ω	Sensitivity (2.83 V / 1 m)	93 dB
Voice coil inductance, Le	0.05 mH	Mechanical Q-factor, Qms	2.94
Effective piston area, Sd	9.6 cm^2	Electrical Q-factor, Qes	1.09
Voice coil diameter	29 mm	Total Q-factor, Qts	0.8
Voice coil height	2.0 mm	Force factor, Bl	2.4 Tm
Air gap height	2.5 mm	Rated power handling*	60 W
Linear coil travel (p-p)	0.5 mm	Magnetic flux density	1.1 T
Moving mass incl. air, Mms	0.45 g	Magnet weight	0.22 kg
		Net weight	0.5 kg

* IEC 268-5, high-pass Butterworth, 2600 Hz, 12 dB/oct.

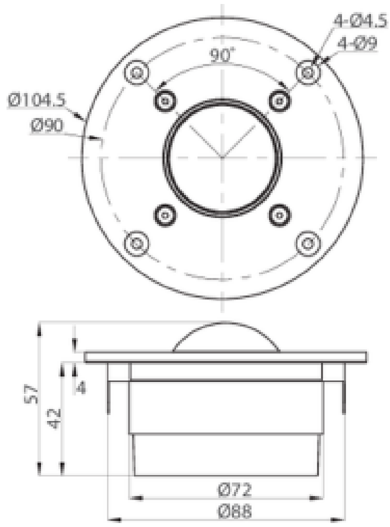


Response Curve :
(Blue) : on axis — (Green) : 30° off-axis — (Red) : 60° off-axis

REV.0 (04.04.2016)

Dayton Audio RST28A-4 1-1/8" Reference Series Aluminum Dome Tweeter 4 Ohm Details

RST28A-4 1-1/8" Reference Series Aluminum Dome Tweeter 4 Ohm



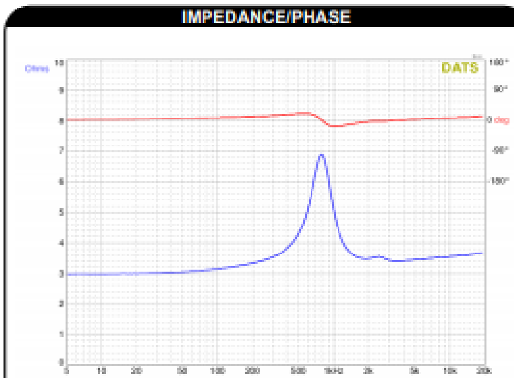
PARAMETERS

Impedance	4 ohms
Re	3.0 ohms
Le	0.03 mH
Fs	775 Hz
Qms	2.15
Qes	1.65
Qts	0.93
Mms	N/A
Cms	N/A
Sd	6.6 cm²
Vd	N/A
BL	N/A
Vas	N/A
Xmax	N/A
VC Diameter	N/A
SPL	92.5 dB @ 2.83V/1m
RMS Power Handling	80 watts
Usable Frequency Range (Hz)	1,500 - 20,000 Hz

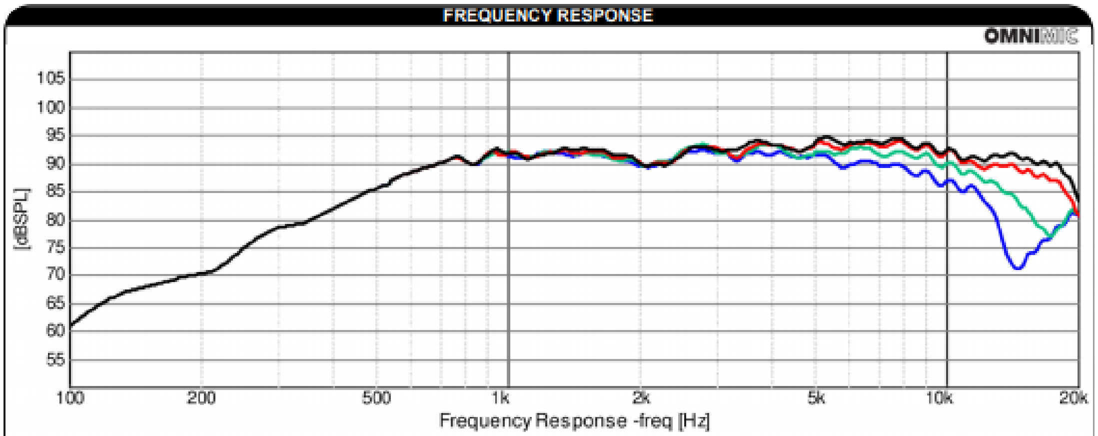
FEATURES

- 1-1/8" aluminum diaphragm offers remarkable clarity without the typical harshness of metal domes
- Exceptional efficiency at 92.5 ±3dB from 1.5 kHz to 19 kHz and a smooth frequency response
- Well-designed phase bridge to balance the response in the upper octave
- Tuned rear chamber and high-quality Ferrofluid for excellent low-end response
- Low-distortion motor system achieves a rare level of transparency
- Matches the performance of even the most expensive audiophile high-frequency transducers

IMPEDANCE/PHASE



FREQUENCY RESPONSE



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

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

SEAS Prestige 92TFF/W (H1318) Fabric Dome Tweeter Details

SEAS PRESTIGE

29TFF/W H1318

29TFF/W is a High Definition precoated fabric dome tweeter with an integrated wide, precoated fabric surround.

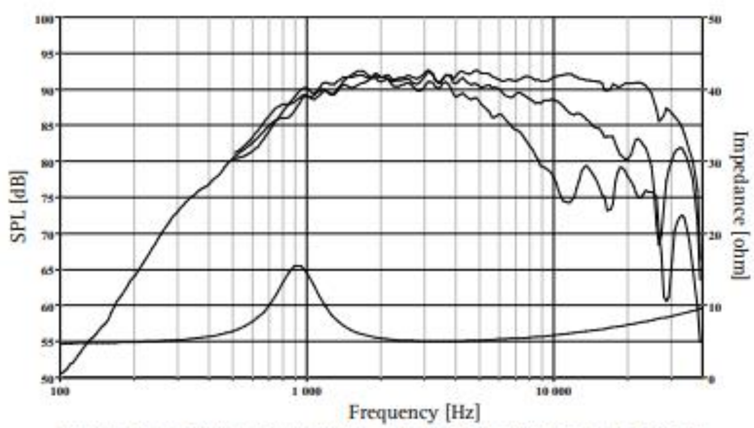
Precoated Sonomex fabric diaphragm allows very tight production tolerances and high consistency.

Wide Sonomex surround for low resonance, excellent mechanical linearity.

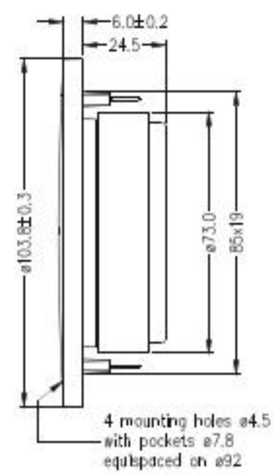
Voice coil windings immersed in magnetic fluid increase short term power handling capacity and reduce the compression at high power levels.

Flexible lead out wires allow this driver to be used with low crossover frequencies.

Two part front plate with smooth, slightly elliptical wave guide made from elastomer provide excellent high frequency response and dispersion. The wave guide conceals (and thus eliminates acoustic effects from) the magnet system screws.



The frequency responses above show measured free field sound pressure in 0, 30, and 60 degrees, mounted in a 0.6m by 0.8m baffle. Input 2.83 Vrms, microphone distance 0.5m, normalized to SPL 1m. The impedance is measured without baffle using a 2V sine signal.



Nominal Impedance	6 Ohms	Voice Coil Resistance	4.7 Ohms
Recommended Frequency Range	2200 - 25000 Hz	Voice Coil Inductance	0.05 mH
Short Term Power Handling *	200 W	Force Factor	3.5 N/A
Long Term Power Handling *	90 W	Free Air Resonance	950 Hz
Characteristic Sensitivity (2.83V, 1m)	92 dB	Moving Mass	0.35 g
Voice Coil Diameter	26 mm	Effective Piston Area	8 cm²
Voice Coil Height	1.5 mm	Magnetic Gap Flux Density	1.8 T
Air Gap Height	2 mm	Magnet Weight	0.25 kg
Linear Coil Travel (p-p)	0.5 mm	Total Weight	0.53 kg

Jul 2007-1 *IEC 268-5, via High Pass Butterworth Filter 2500Hz 12 dB/oct. T29-001

SEAS reserves the right to change technical data

RoHS compliant product www.seas.no

2 Channel Amplifier Stereo Audio Amp Mini Hi-Fi Class D Integrated TPA3116 Amp for Home Speakers 50W x 2, with 19V 4.74A Power Supply – Fosi Audio V1.0B Black Details

TPA3116D2 15-W, 30-W, 50-W Filter-Free Class-D Stereo Amplifier Family With AM Avoidance

1 Features

- Supports Multiple Output Configurations
  - 2 × 50 W Into a 4-Ω BTL Load at 21 V (TPA3116D2)
  - 2 × 30 W Into a 8-Ω BTL Load at 24 V (TPA3118D2)
  - 2 × 15 W Into a 8-Ω BTL Load at 15 V (TPA3130D2)
- Wide Voltage Range: 4.5 V to 26 V
- Efficient Class-D Operation
  - >90% Power Efficiency Combined With Low Idle Loss Greatly Reduces Heat Sink Size
  - Advanced Modulation Schemes
- Multiple Switching Frequencies
  - AM Avoidance
  - Master and Slave Synchronization
  - Up to 1.2-MHz Switching Frequency
- Feedback Power-Stage Architecture With High PSRR Reduces PSU Requirements
- Programmable Power Limit
- Differential and Single-Ended Inputs
- Stereo and Mono Mode With Single-Filter Mono Configuration
- Single Power Supply Reduces Component Count
- Integrated Self-Protection Circuits Including Overvoltage, Undervoltage, Overtemperature, DC-Detect, and Short Circuit With Error Reporting
- Thermally Enhanced Packages
  - DAD (32-Pin HTSSOP Pad Up)
  - DAP (32-Pin HTSSOP Pad Down)
- –40°C to 85°C Ambient Temperature Range

2 Applications

- Mini-Micro Component, Speaker Bar, Docks
- After-Market Automotive
- CRT TV
- Consumer Audio Applications

3 Description

The TPA31xxD2 series are stereo efficient, digital amplifier power stage for driving speakers up to 100 W / 2 Ω in mono. The high efficiency of the TPA3130D2 allows it to do 2 × 15 W without external heat sink on a single layer PCB. The TPA3118D2 can even run 2 × 30 W / 8 Ω without heat sink on a dual layer PCB. If even higher power is needed the TPA3116D2 does 2 × 50 W / 4 Ω with a small heat-sink attached to its top side PowerPAD. All three devices share the same footprint enabling a single PCB to be used across different power levels.

The TPA31xxD2 advanced oscillator/PLL circuit employs a multiple switching frequency option to avoid AM interferences; this is achieved together with an option of either master or slave option, making it possible to synchronize multiple devices.

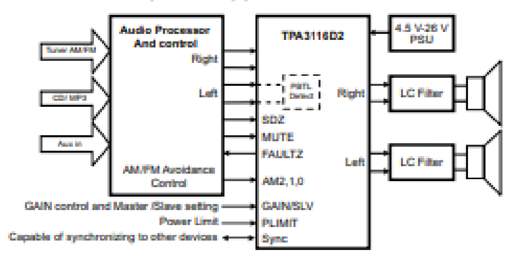
The TPA31xxD2 devices are fully protected against faults with short-circuit protection and thermal protection as well as overvoltage, undervoltage, and DC protection. Faults are reported back to the processor to prevent devices from being damaged during overload conditions.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPA3116D2	DAD (32)	11.00 mm × 6.20 mm
TPA3118D2 TPA3130D2	DAP (32)	11.00 mm × 6.20 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Simplified Application Circuit



6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

		MIN	MAX	UNIT
Supply voltage, V_{CC}	PV_{CC}, AV_{CC}	–0.3	30	V
Input voltage, V_I	INPL, INNL, INPR, INNR	–0.3	6.3	V
	PLIMIT, GAIN / SLV, SYNC	–0.3	GVDD+0.3	V
	AM0, AM1, AM2, MUTE, SDZ, MODSEL	–0.3	PVCC+0.3	V
Slew rate, maximum[2]	AM0, AM1, AM2, MUTE, SDZ, MODSEL		10	V/ms
Operating free-air temperature, T_A		–40	85	°C
Operating junction temperature , T_J		–40	150	°C
Storage temperature, T_{stg}		–40	125	°C

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) 100 kΩ series resistor is needed if maximum slew rate is exceeded.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[2]	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. .

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

				MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	PV_{CC}, AV_{CC}		4.5		26	V
V_{IH}	High-level input voltage	AM0, AM1, AM2, MUTE, SDZ, SYNC, MODSEL		2			V
V_{IL}	Low-level input voltage	AM0, AM1, AM2, MUTE, SDZ, SYNC, MODSEL				0.8	V
V_{OL}	Low-level output voltage	FAULTZ, $R_{PULL-UP}$ = 100 kΩ, PV_{CC} = 26 V				0.8	V
I_{IH}	High-level input current	AM0, AM1, AM2, MUTE, SDZ, MODSEL (V_I = 2 V, V_{CC} = 18 V)				50	µA
R_L(BTL)	Minimum load Impedance	Output filter: L = 10 µH, C = 680 nF	TPA3116D2, TPA3118D2	3.2	4		Ω
			TPA3130D2	5.6	8		
R_L(PBTL)		Output filter: L = 10 µH, C = 1 µF	TPA3116D2, TPA3118D2	1.6			
			TPA3130D2	3.2	4		
L_o	Output-filter Inductance	Minimum output filter inductance under short-circuit condition		1			µH

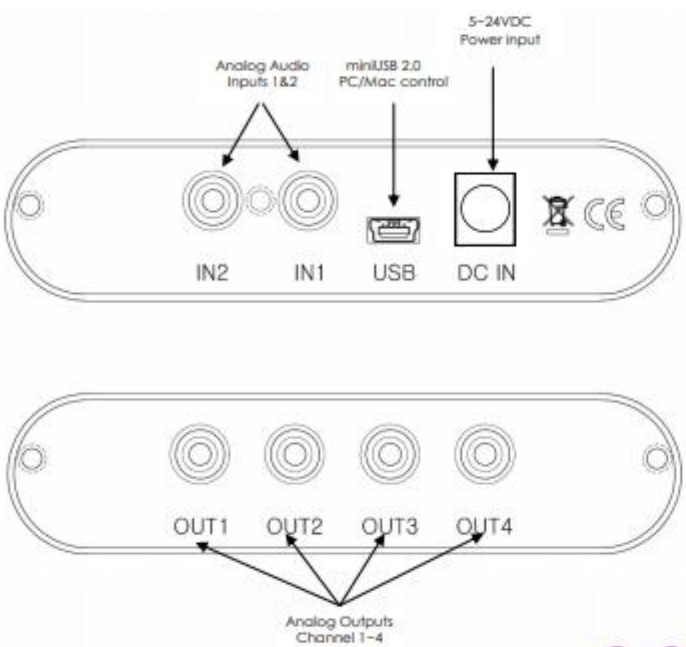
miniDSP 2x4 Digital Signal Processor Details

miniDSP 2x4 Box

HARDWARE SPECIFICATIONS

Item	Description
Digital Signal Processor Engine	28/56 bit Digital Signal Processor Engine / Double precision processing
Host Processor	48MHz microcontroller
Sample rate	48kHz
ADC/DAC Data resolution	24 bits
Analog Audio Input	Unbalanced input, RCA terminated
Maximum input level	0.9Vrms (RevA) or 2Vrms (RevB)
Dynamic range ADC, un-weighted	>98dB
Input impedance	6Kohms
Analog Audio Output	Unbalanced input, RCA terminated
Maximum level, unbalanced, <1% THD	0.9Vrms (2.5Vpp)
Dynamic range DAC, un-weighted	>98dB
Output impedance	560ohms
Certification	CE / FCC certified - ROHS compliant
Power supply	Powered from USB cable 5 ~24Vdc input via DC 2.1mm round connect Current requirement: 150mA @5V
Dimensions (H x W x D)	26x107x94 mm

MECHANICAL SPECIFICATIONS



Features and specifications are subject to change without prior notice

www.minidsp.com

WinSpeakerz Frequency Response Plots

Dayton Audio RS225-8 8" Reference Woofer 8 Ohm WinSpeakerz Plots

Parameters: (Distance – 1m, Power – 28.5W)

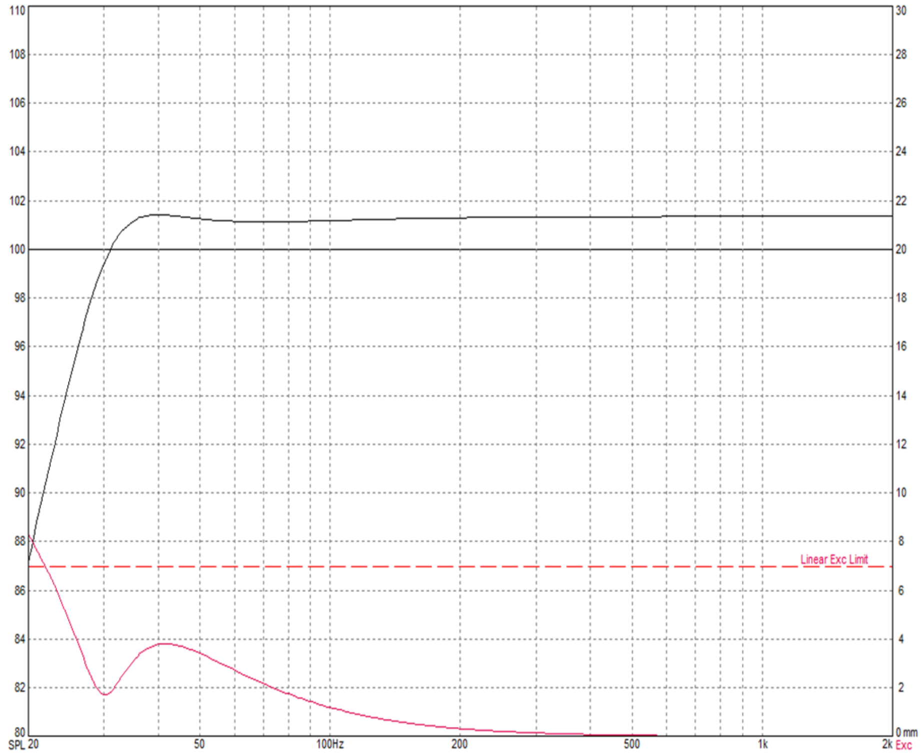


Figure 9: Frequency Response of Bass Boosted Dayton System

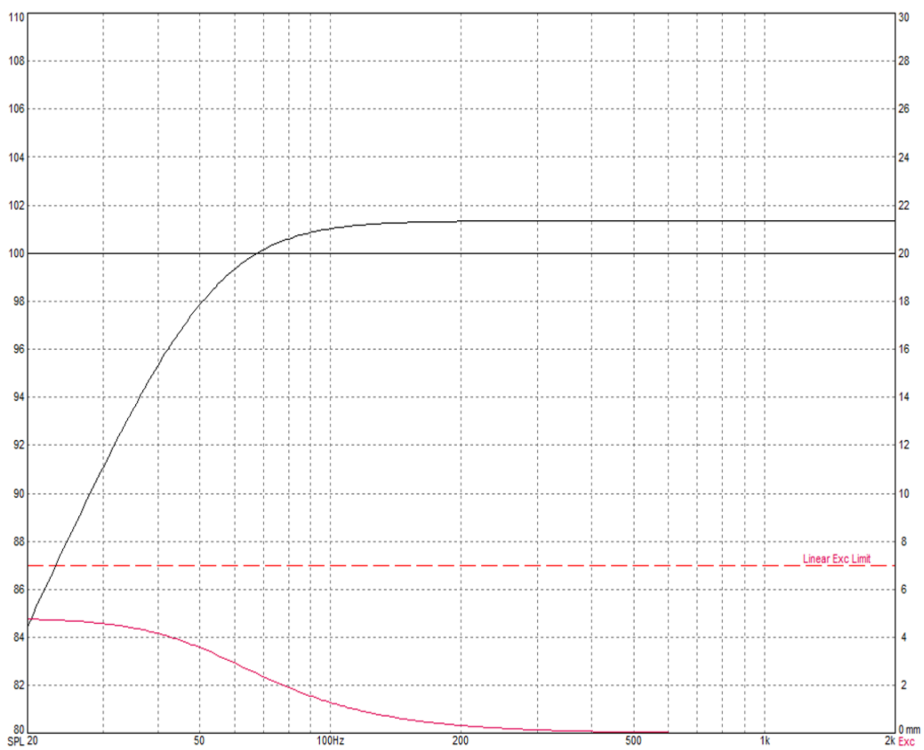


Figure 10: Frequency Response of Sealed Dayton System

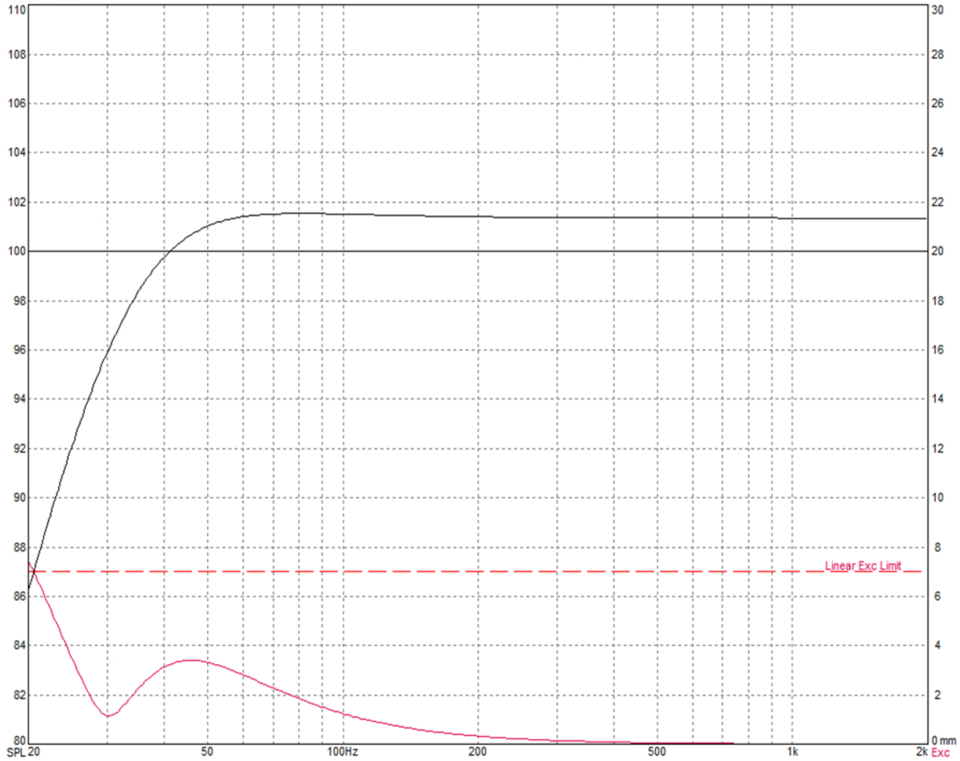


Figure 11: Frequency Response of Ported Dayton System

Visaton W200s-4 8" Woofer with Treated Paper Cone 4 Ohm WinSpeakerz Plots

Parameters: (Distance – 3m, Power – 28.5W)

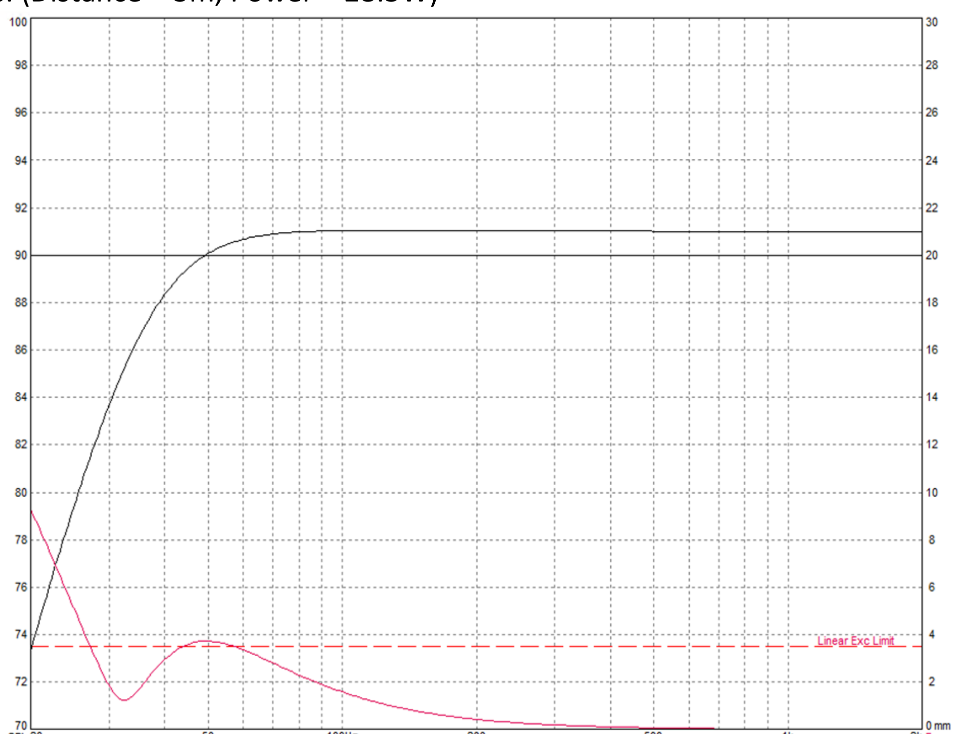


Figure 14: Frequency Response of Ported Visaton System

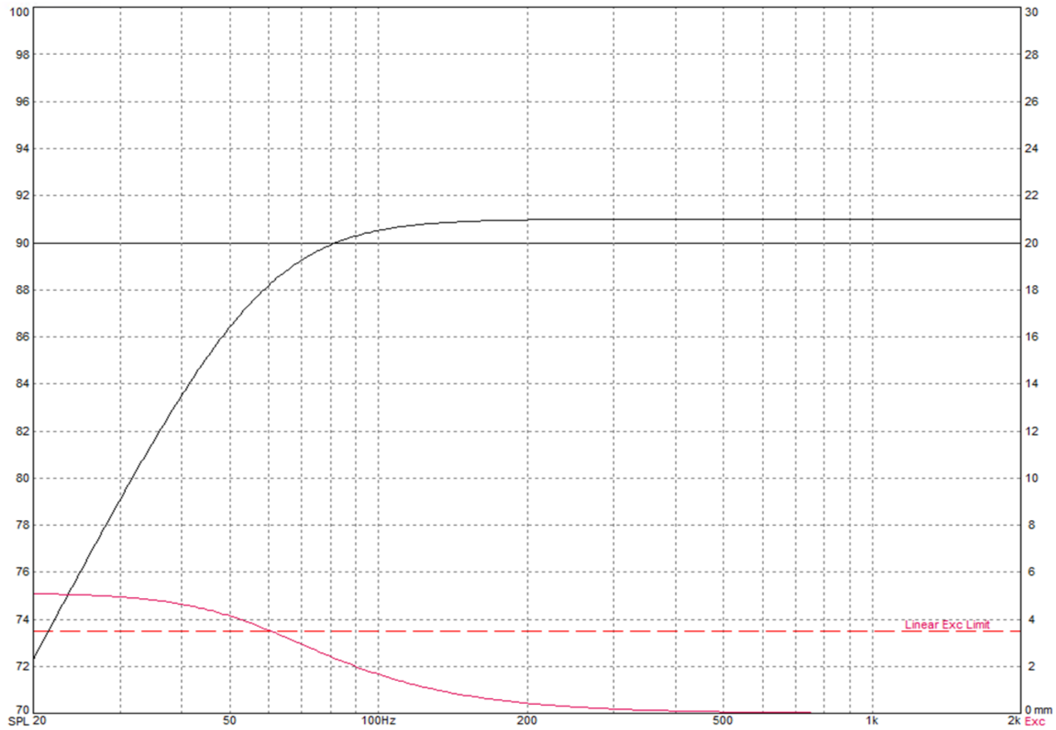


Figure 15: Frequency Response of Sealed Visaton System

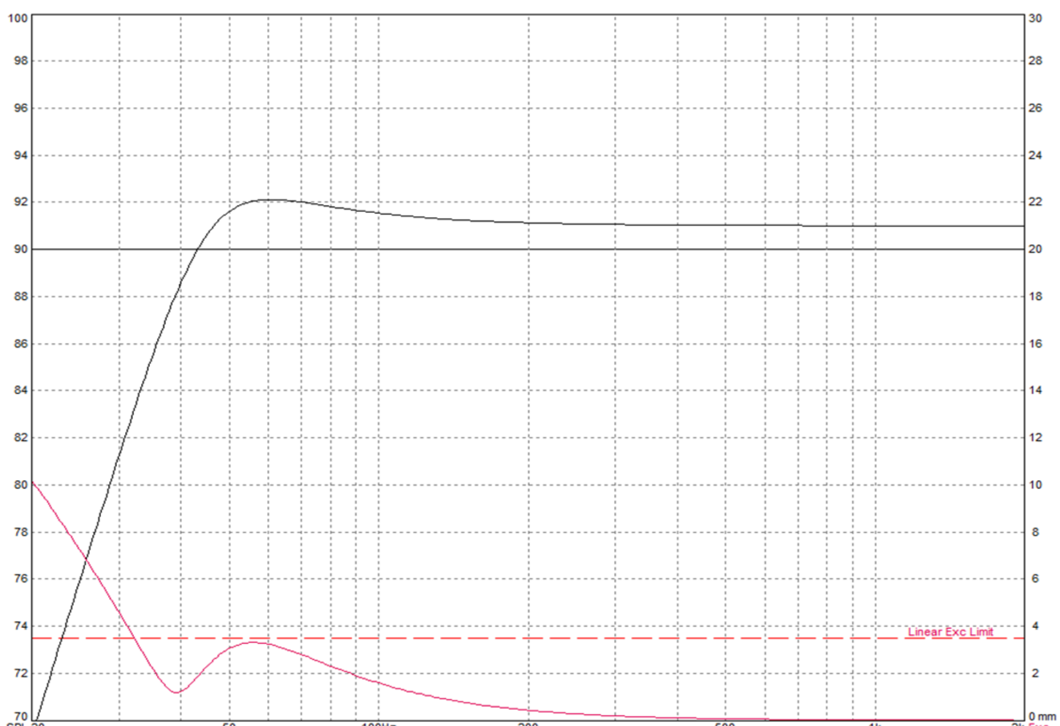


Figure 16: Frequency Response of Bass Boosted Visaton System

HiVi M8N 8” Aluminum / Magnesium Woofer WinSpeakerz Plots

Parameters: (Distance – 3m, Power – 28.5W)

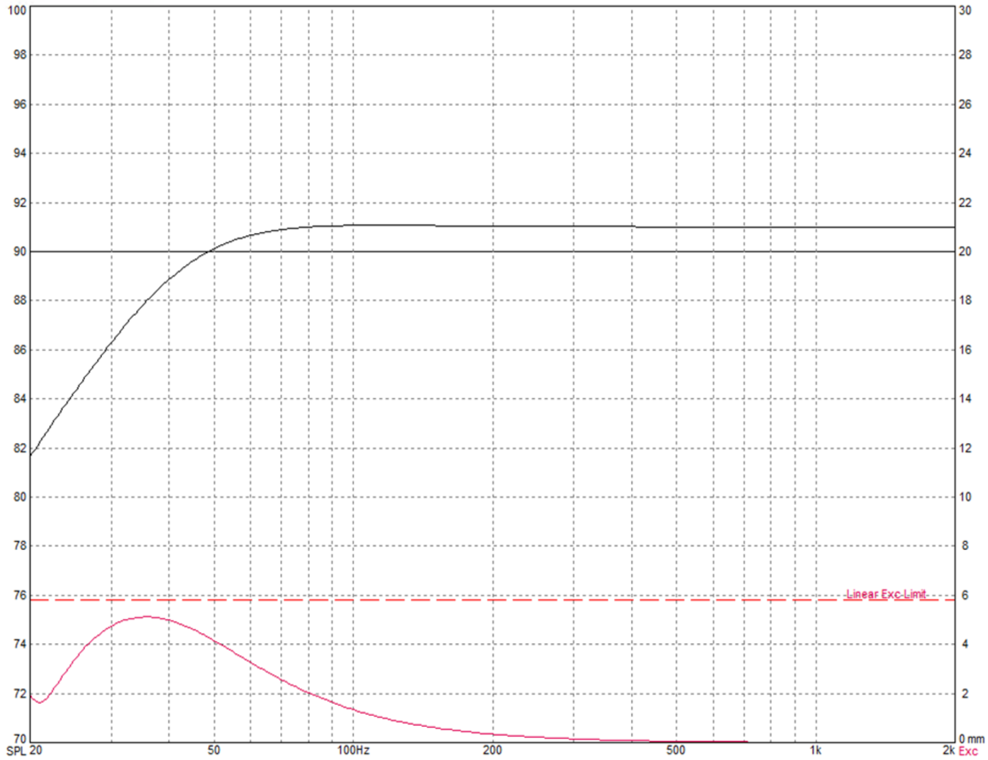


Figure 19: Frequency Response of Ported HiVi System

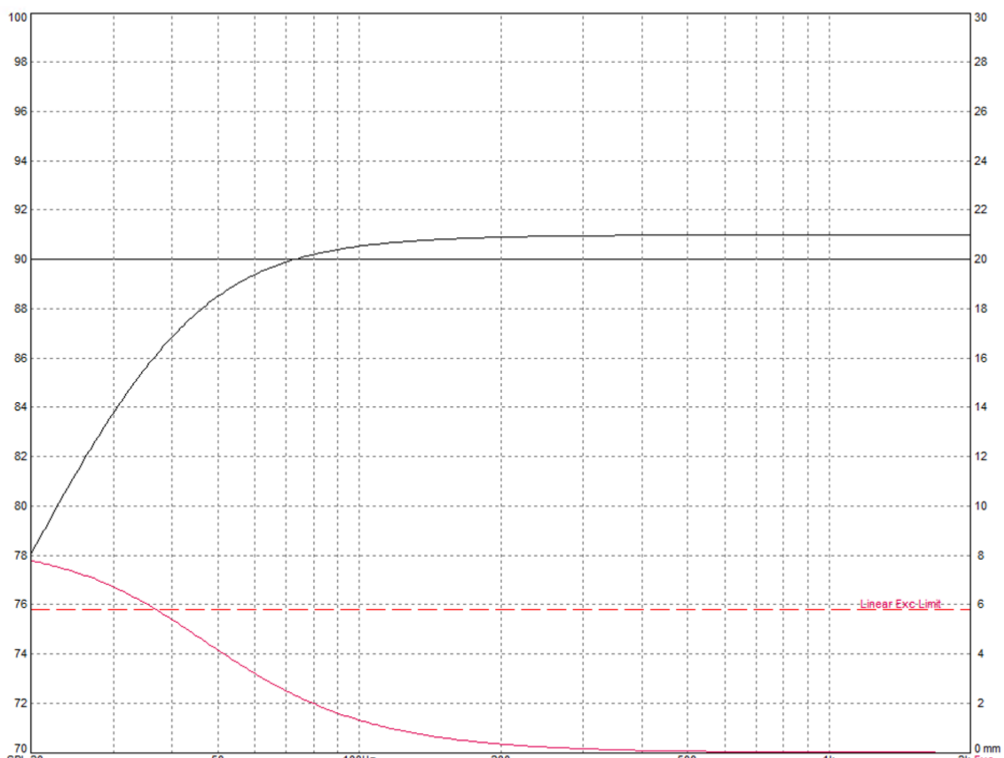


Figure 20: Frequency Response of Sealed HiVi System

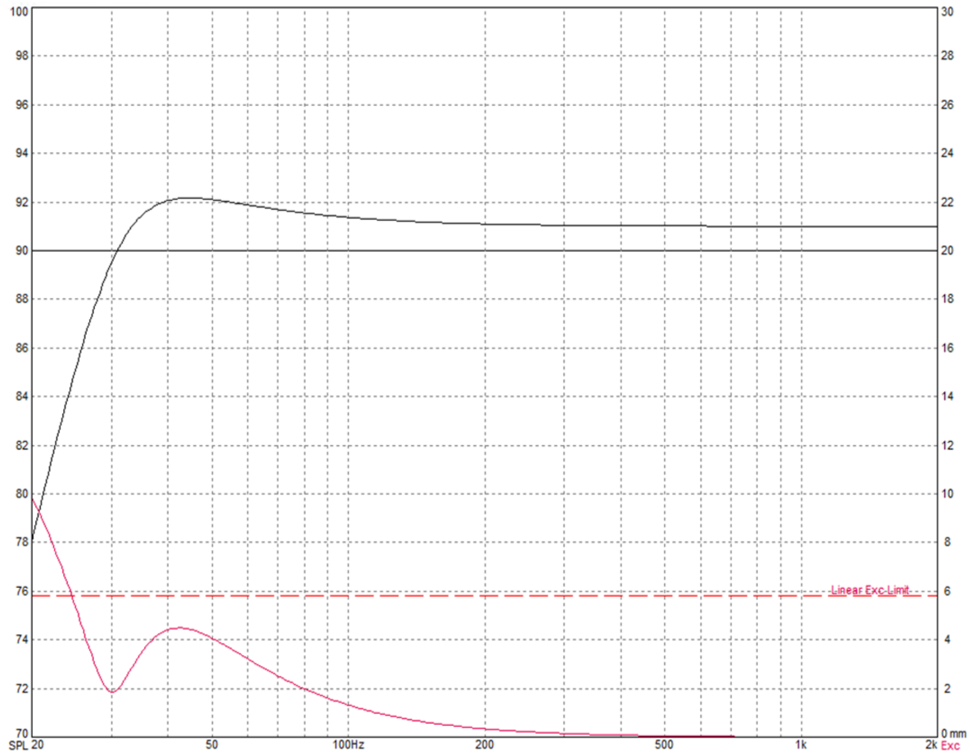


Figure 21: Frequency Response of Bass Boosted HiVi System