The Krakens
FA 4740

Renata Putzig

2/04/13

Table of Contents

Functional Description

I am building a pair of loudspeakers for casual listening, film viewing, and mixing. The speakers will need to be able to look natural and fit comfortably in a medium or small room. They will be listened to for long periods of time, which requires them to have low listening fatigue. These speakers must also have an acceptably low enough frequency response to be used for movies. I would like to achieve this without the use of a subwoofer to better display the stereo image. The speakers need a good depth of field and transient response. They will be used to play a wide variety of genres. They need to be portable and durable enough to be easily moved by one or two people and must be able to adapt to unknown future spaces. I would also like to use solid cherry for aesthetic reasons as well as to increase the ease of repair if damage occurs. I would also like to keep costs down; I would like to build these speakers for less than $1000.

Design Goals

Size & Shape

The speakers will need to be large enough to go down to 50 Hz while still being small enough to fit comfortably in a small room, such as a bedroom. I plan on using them in a small bedroom or living room. The horizontal space they take up will be minimized to make them easier to place in a variety of rooms. While speakers with diamond shaped fronts reduce internal box resonances and diffusion issues, I will build a rectangular box due to the difficulty of diamond shaped box construction. The edges of the box will be rounded to help with diffraction[1]. The box will be 14 ¾ ” wide by 24 ¾” tall by 21 ¾ ”. This makes them just small enough for one strong person to carry.

SPL Output/Power

The speakers need to have an SPL of 85dB. I listened and measured a variety of songs on my current speakers and could not foresee myself needing anything louder than 85dB. I found myself listening most often at 70dB. These speakers will most likely be used in a house with other housemates nearby, so 85dB is unlikely to be utilized often, but I would like them to be capable of this level if the opportunity arises and available for future use. Again, these speakers will only be used in small or medium sized rooms; loud SPL output will not be needed due to the distance of the listening position either.

[1] Philip Newell, and Keith Holland, Loudspeakers for Music Recording and Reproduction, (Amsterdam: Elsevier Ltd., 2007), 90-91.

Most drivers are in the 90-95dB sensitivity range, meaning that I will need a 250 watt amp to achieve an 85 dB average at 2 meters with a crest factor of 20dB[2]. I currently have a 100 watt amplifier I plan to use with these speakers, which gives me about an 82dB average at 2 meters.

Bandwidth

My speakers will range from 50 Hz to 20 kHz. At 50 Hz, the desirable "rumble" disappeared completely in my test songs. This is one of my top priorities when designing these speakers. As mentioned earlier, I do not plan to use a subwoofer with this system. While boosting the lower frequency spectrum, subwoofers also distract and interfere with the carefully integrated stereo loudspeaker system[3]. Therefore, the speakers must cover a bandwidth that meets my requirements for film viewing and music listening on their own.

Directivity

These speakers need to have a good horizontal off axis response, as they will often be used for casual listening and film, where the listener is either moving around or not sitting centered between the speakers. I intend to use a ribbon tweeter because of their clarity and overall pleasant sound. Ribbons are also known for their narrow vertical dispersion and wide horizontal dispersion. This will limit the undesirable celling and floor reflections while still providing coverage to the entire room. This also creates a considerable difference in high-end frequency response when comparing standing vs. sitting listening positions. However, this should not be a problem as long as they are set up in the room properly.

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[2] Bob, Katz. Digital Domain, "Part II: How To Make Better Recordings in the 21st Century - An Integrated Approach to Metering, Monitoring, and Leveling Practices.." Last modified September 2000. Accessed May 4, 2013. http://www.digido.com/how-to-make-better-recordings-part-2.html.

[3] David Moulton, Total Recording, (KIQ Productions Inc., 2000), 314.

Visual Aesthetics

The speakers should blend well with any room, yet still catch the eye. To accomplish this I intend to use solid cherry wood for all sides of the box with natural finishing oil. This will make them more durable and conceal damage better than the alternative cherry colored veneer. They should seem inviting, happy, and warm.

Design Priorities

The first tradeoff to be made is SPL and budget, as there is not an absolute reason they need to play at 85 dB and I have more money available. The most important aspects are the size, sound field, transient response, and low fatigue. I would also like to use a ribbon tweeter, as the generally have a relaxed and unique sound as compared to other tweeter types.

The following are the features of my design in order of importance.

1. Sound field/good transients/low fatigue
2. Bass response
3. Use of a ribbon tweeter
4. Visual aesthetics
5. Size
6. SPL
7. Budget

Technical Details

Baffle Step

The calculated baffle step frequency for my speaker is 309 Hz (f (frequency at 3dB) =4560”(speed of sound in inches per second)/14.75 (width of baffle in inches). This means that theoretically, frequencies above this point will be 3dB louder due to the speaker radiating in half space rather than full space above this point[4]. However, this works out to be a non-issue in my design, as my crossover point was finalized to be about 300Hz and my midrange was naturally 2.5 dB quieter than my woofer. The speaker had a smooth response with out the use of a baffle step compensation circuit.

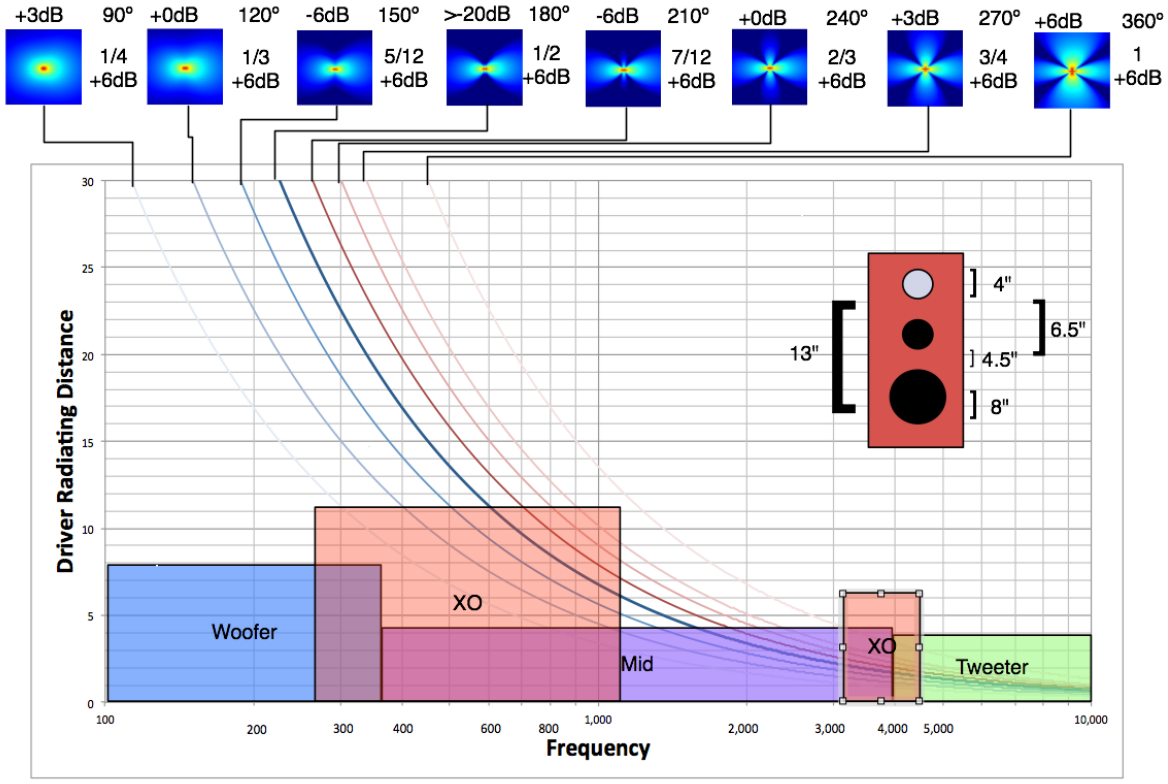
Low Frequency Alignment

In order to have the best transient response possible, I decided to build a sealed box. A sealed box has an accurate transient response when properly tuned. The trapped air inside a sealed box design makes the driver act like a spring and opposes the motion of the driver. A sealed box system is critically damped when the cabinet size and driver resonant frequency are matched so that the overall response is 6 dB down at the resonant frequency. This creates an excellent transient response with no perceptible ringing[5].

[4] John Murphy, *Introduction to Loudspeaker Design*, (Andersonville, TN: True Audio, 1998), 69.

[5] Philip Newell, and Keith Holland, Loudspeakers for Music Recording and Reproduction, (Amsterdam: Elsevier Ltd., 2007), 67-68.

Diffraction effects



All drivers are centered on the baffle to create a symmetrical off axis response. The edges of the cabinet are rounded over to smooth the transition between half space and full space. While this does not eliminate the edge diffraction effect, it does make the transition smoother and improves the off-axis driver response that was otherwise negatively affected by edge diffraction[6].

Wall Construction & Bracing

All sides of the speaker cabinet are constructed with a layer of ½" underlay, 1/8" mass loaded vinyl, and ¾" hardwood cherry. The combination of three different materials reduces the resonance of the cabinet and makes the cabinet more ridged. This will greatly decrease the

[6] Philip Newell, and Keith Holland, Loudspeakers for Music Recording and Reproduction, (Amsterdam: Elsevier Ltd., 2007), 90-91.

driver/box interaction as compared to using only solid wood. The midrange woofer cabinet is constructed of a single layer of ½” underlay. All edges of both the inner and main cabinets are sealed with caulk to ensure no air leakage or interactions between the midrange and woofer. The back of the midrange cabinet has two supports bracing it to the back of the main cabinet. Drafts of the design can be found in the Appendix.

Driver Selection

Due to my requirement of a response to 50 Hz in a sealed box and use of a ribbon tweeter, I found it necessary to make a 3-way system. There are few drivers that are engineered for sealed boxes; Finding drivers proved to be a challenge. I was unable to find a ribbon tweeter that went low enough to work with any of the woofers that met my design requirements. I decided to add a midrange driver to fill this frequency gap.

I chose the SB Acoustics SB23NRXS45 for my woofer. It has a F3 of 50 Hz in a properly tuned cabinet and a very flat frequency response up to 1 kHz. It is also one of the least expensive drivers I found that were in my price range and designed for a sealed box.

I chose the Seas Prestige MCA12RC H1304 for my midrange. It has a good response from 300 Hz to about 4 kHz. This driver has more power handling than I need and excellent off-axis response when compared to other midranges in the same price range.

I chose the Fountek NEOX2.0 as my tweeter. It has a very flat frequency response and is on sale, making it cheaper than much of its competition. Of course, it is a ribbon, which fulfills my design requirements.

Woofer Analysis & Selection

The woofers I considered in my speakers include the SB Acoustics XC35 6.", the SB Acoustics XS45 8", the Seas Prestige L16RN-SL, the Audax HM210C0, and the Scanspeak 22W/8534G00 Discovery 8". All these have resonant frequencies below 50Hz and a low Qts. A low Qts factor is linked to driver compatibility with sealed boxes.[7]

[7] Vance Dickason, *Loudspeaker Design Cookbook*, (Peterborough, NH: Audio Amateur Press, 2006), 34.

Driver	Diameter	Sensitivity	Rated Power Handling	SPL at rated pow	Modeled bandwidth in 1.7 ft^3 box (F3 to max XO)	Cost
SB Acoustics SB17NRXC35-8	6.5"	92	60	109.8	85-2500 Hz	$65
SB Acoustics SB23NRXS45-8	8"	88.5	60	106.3	50-1000 Hz	$99
Seas Prestige L16RN-SL H1480	5"	84	80	103	58-2000 Hz	$98
Audax HM210C0	8"	90	70	108.5	58?-2000 Hz	$137
Scanspeak 22W/8534G00	8"	88.8	70	107.3	54-1000 Hz	$88

Woofer #1 – SB Acoustics SB17NRXC35-8

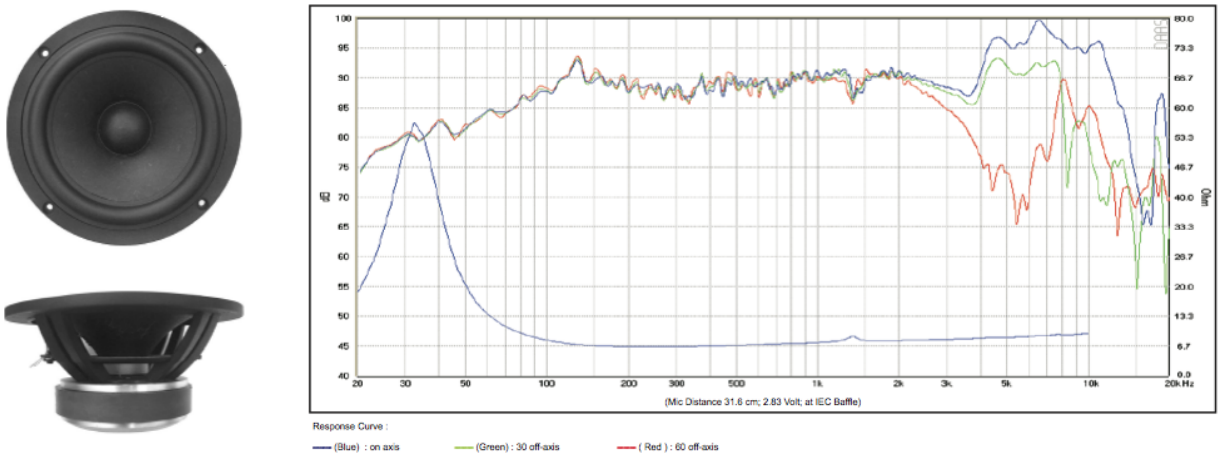


Figure 1.1 - SB Acoustics XC35 Frequency Response

Figure 1.2 through 1.4 below shows the box response with a different Qtc of the SB Acoustics XC35. This is a 6” woofer that costs about $60, making it well within my price range and acceptable for my design. However, modeling this driver in the box volume I want gives the driver a roll off well above my desired bass requirement. See the Appendix for other specifications.

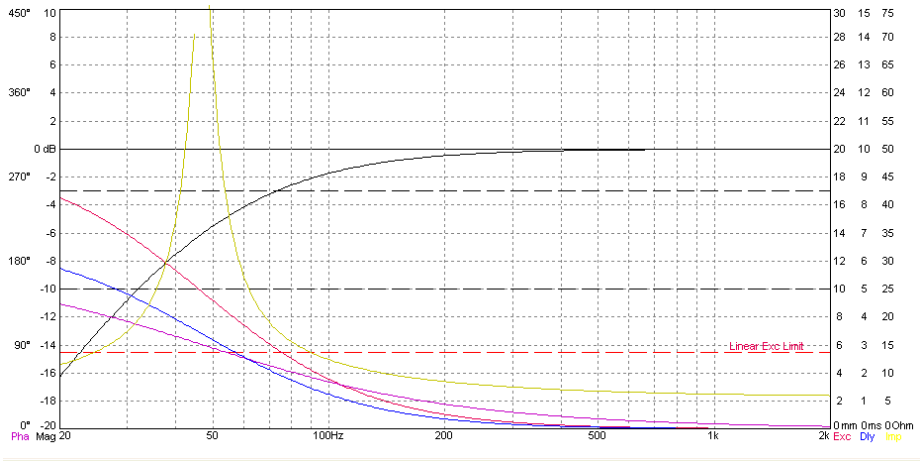


Figure 1.2: SB Acoustics XC35 Qts=.5

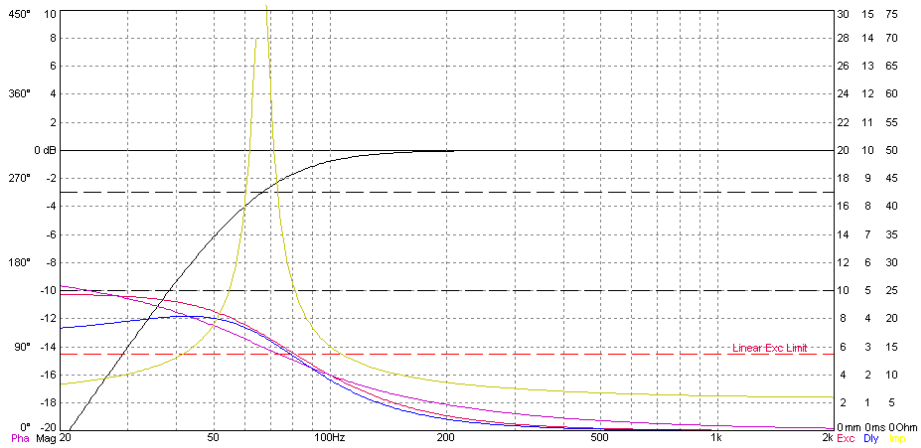


Figure 1.3: SB Acoustics XC35 Qts=.707

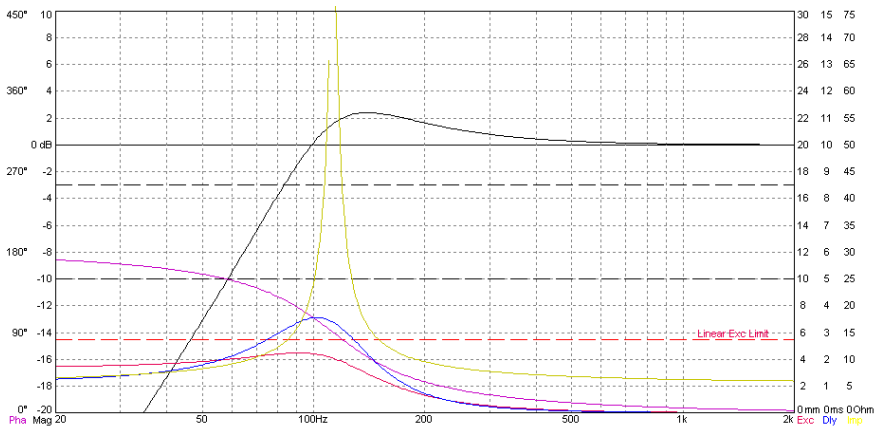


Figure 1.4: SB Acoustics XC35 Qts=1.2

Woofer #2 – SB Acoustics SB23NRXS45-8

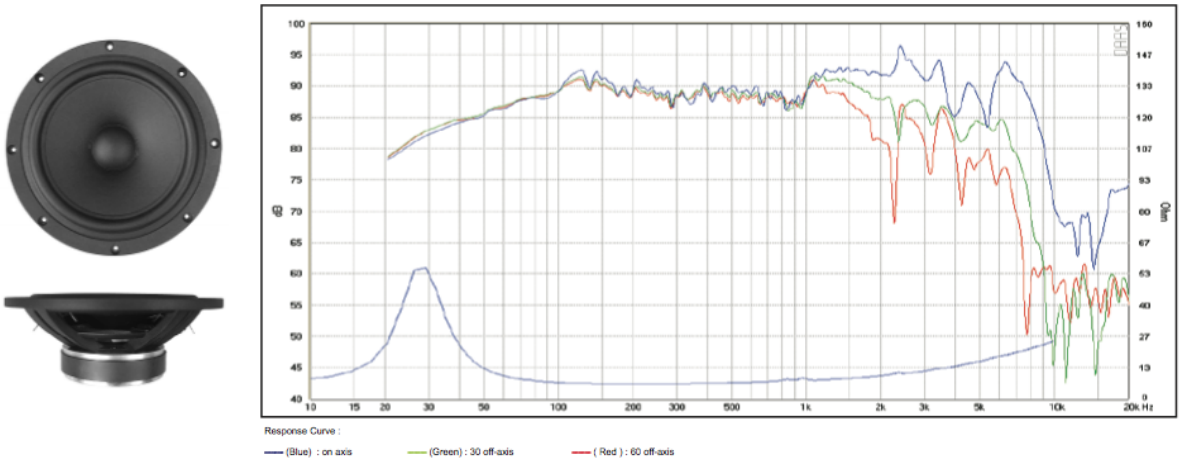


Figure 2.1 - SB Acoustics SB23NRXS45-8 Frequency Response

Figure 2.2 through 2.4 below shows the box response with a different Qtc of the SB Acoustics SB23NRXS45-8. This is an 8” woofer that costs about $100. While this driver is more expensive, it offers significantly lower frequency response with an F3 of 50 Hz, which satisfies my requirements. It also has a smoother frequency response. See the appendix for other specifications.

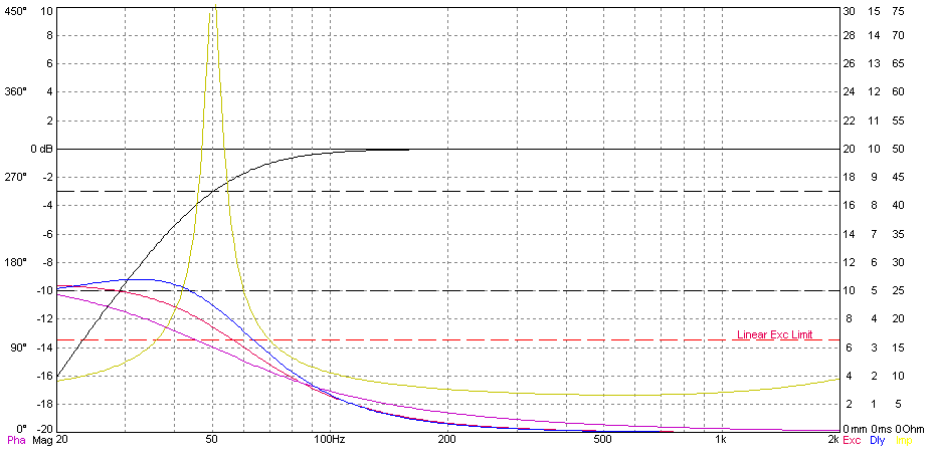


Figure 2.2: SB Acoustics XS45 Qts=.5

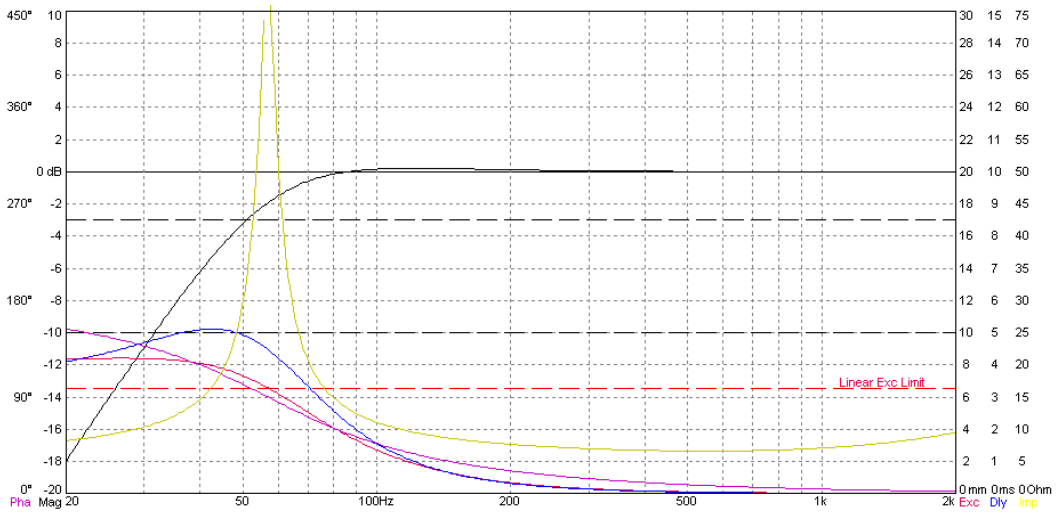


Figure 2.3: SB Acoustics XS45 Qts=.707

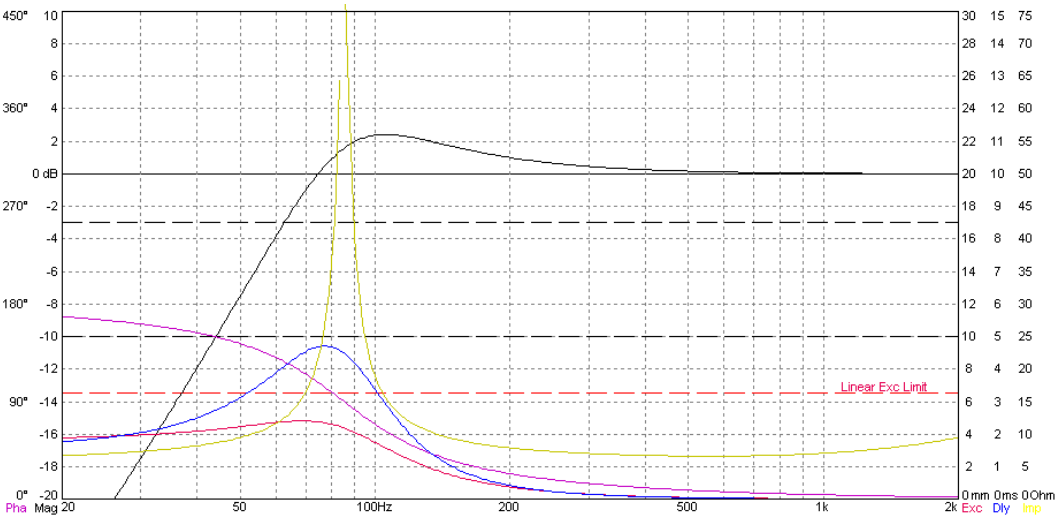


Figure 2.4: SB Acoustics XS45 Qts=1.2

Woofer #3 – Seas Prestige L16RN-SL 6”

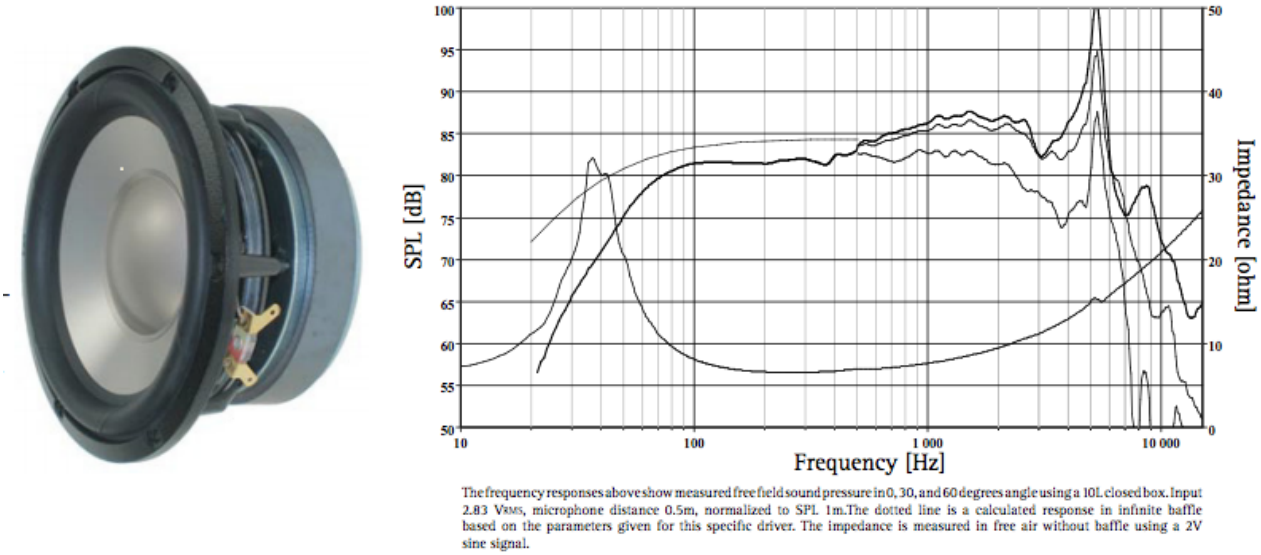


Figure 3.1 - Seas Prestige L16RN-SL Frequency Response

Figure 3.2 through 3.4 below shows the box response with a different Qtc of the Seas Prestige L16RN-SL. This is a 6” woofer that costs about $100. The specs look very promising, as this woofer is designed specifically for sealed boxed and is only recommended for sealed boxes. However, modeling the speaker only gave an F3 of 58 Hz. See the appendix for other specifications.

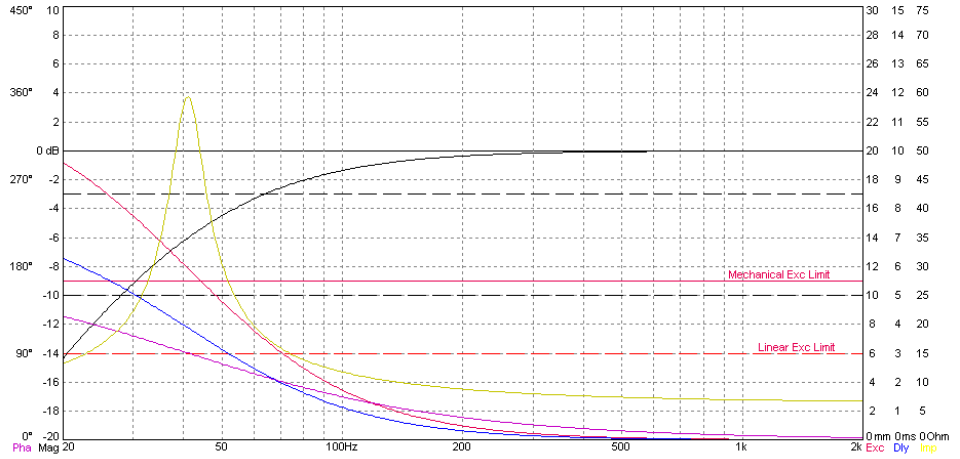


Figure 3.2: Seas Prestige L16RN-SL Qts=.5

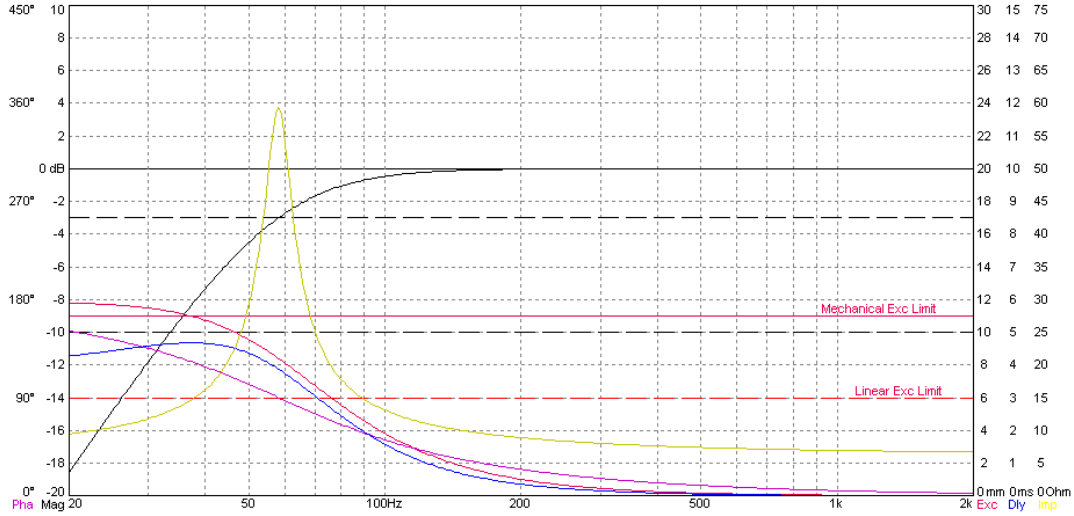


Figure 3.3: Seas Prestige L16RN-SL Qts=.707

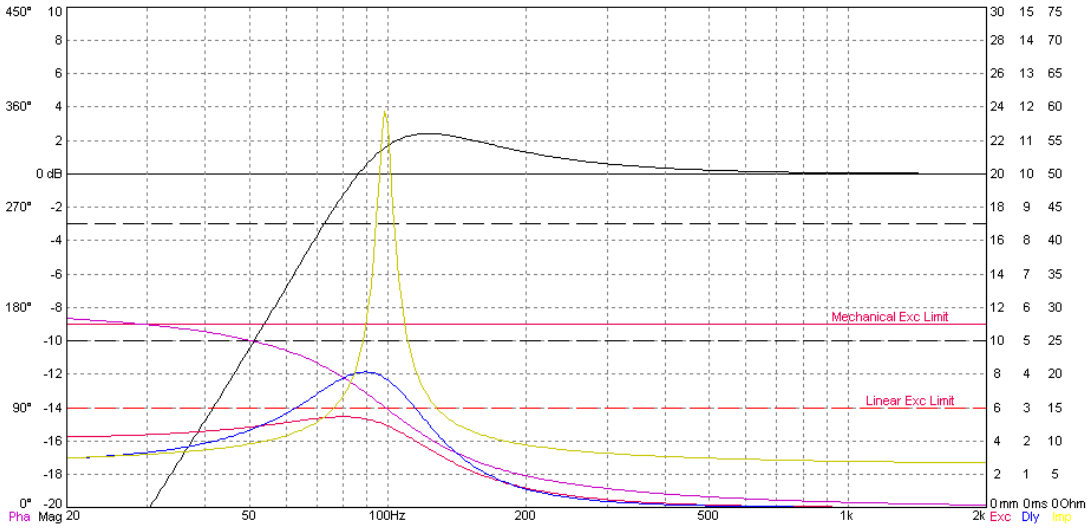


Figure 3.4: Seas Prestige L16RN-SL Qts=1.2

Woofer #4 – Audax HM210C0 8”

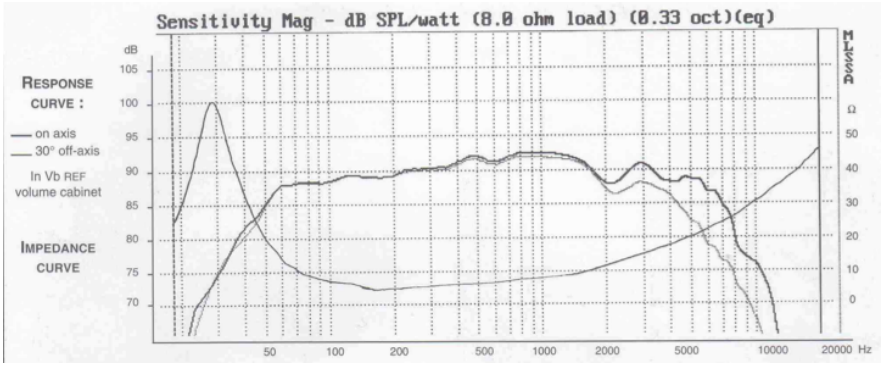


Figure 4.1- Audax HM210C0 Frequency Response

This is an 8” woofer that costs $137. While the specs looked promising, I soon discovered what happens when you put a driver designed for a vented boxed in a sealed box. The boxes for the given Qtc in the following figures are smaller than the space the driver takes up. All of the response graphs shown are impossible. This driver will not work in a sealed box. See the appendix for other specifications.

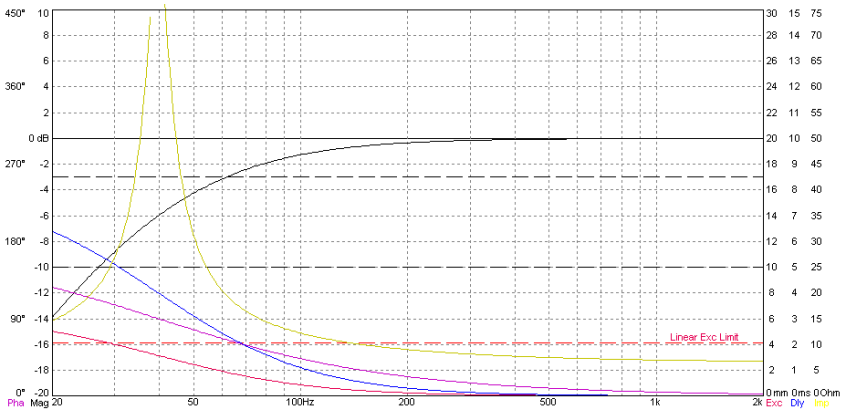


Figure 4.2: Audax HM210C0 Qts=.5

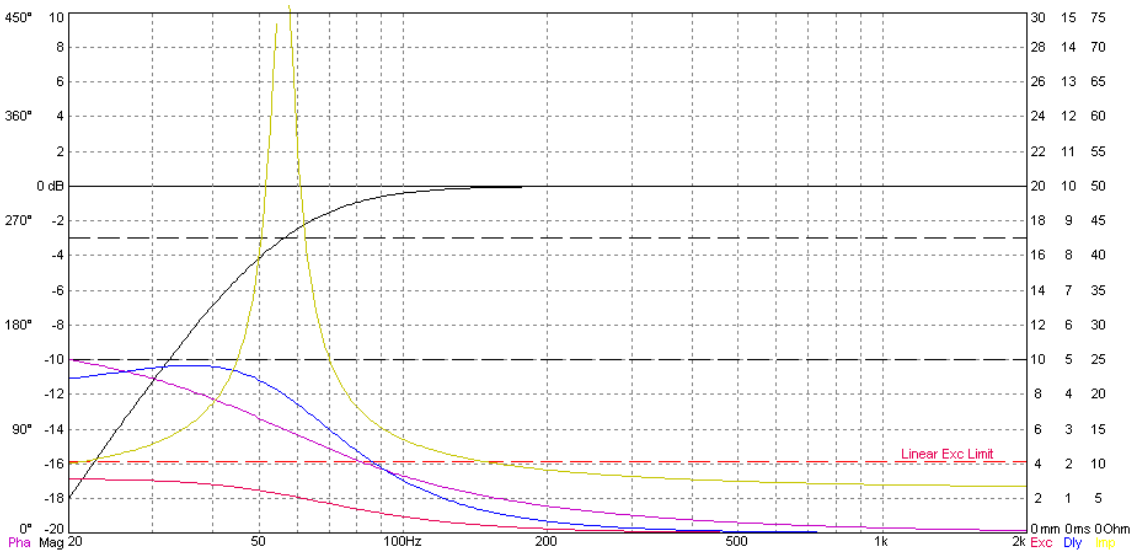


Figure 4.3: Audax HM210C0 Qts=.707 (impossible box)

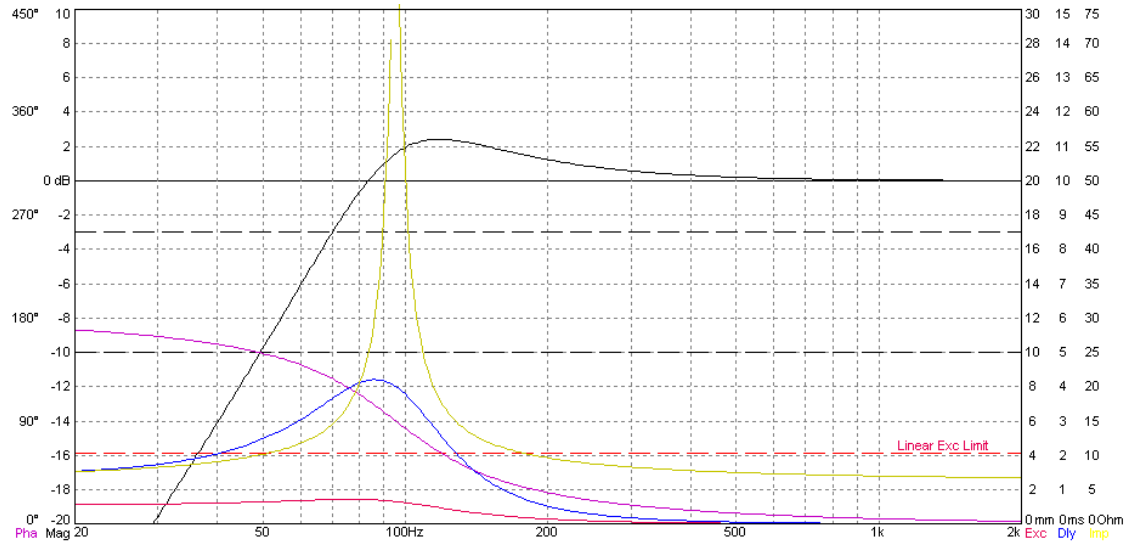


Figure 4.4: Audax HM210C0 Qts=1.2 (impossible box)

Woofer #5 – Scanspeak 22W/8534G00 Discovery 8"

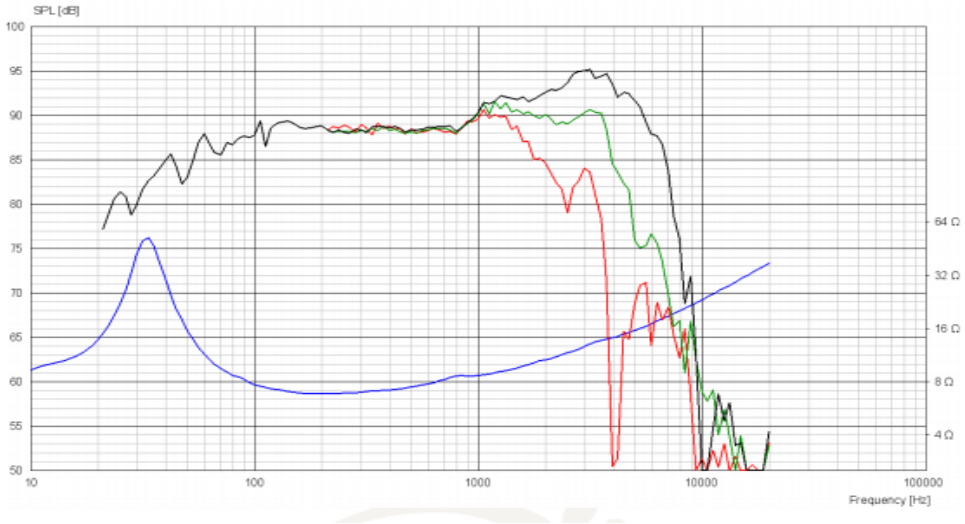


Figure 5.1- Scanspeak 22W/8534G00 Discovery Frequency Response

Figure 5.2 through 5.4 below shows the box response with a different Qtc of the 8" Scanspeak Discovery. This is an 8" woofer that costs $88. See the appendix for other specifications. This driver had the 2nd lowest modeled bass response (F3 of 54 Hz) of the drivers considered.

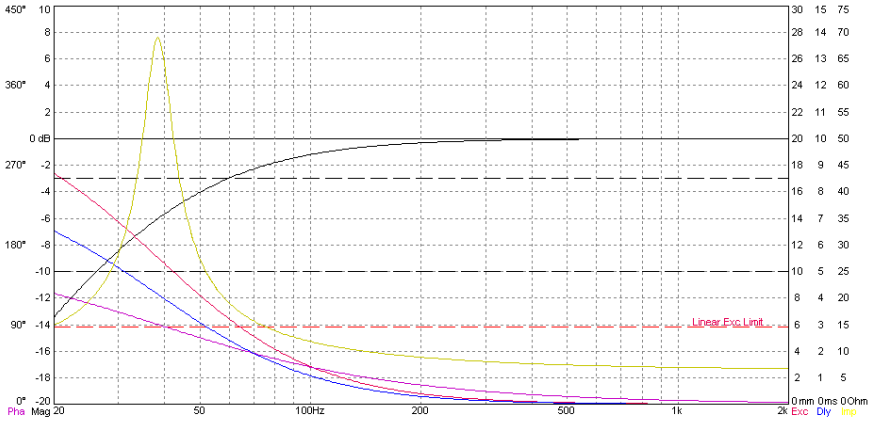


Figure 5.2: Scanspeak 22W/8534G00 Discovery Qts=.5

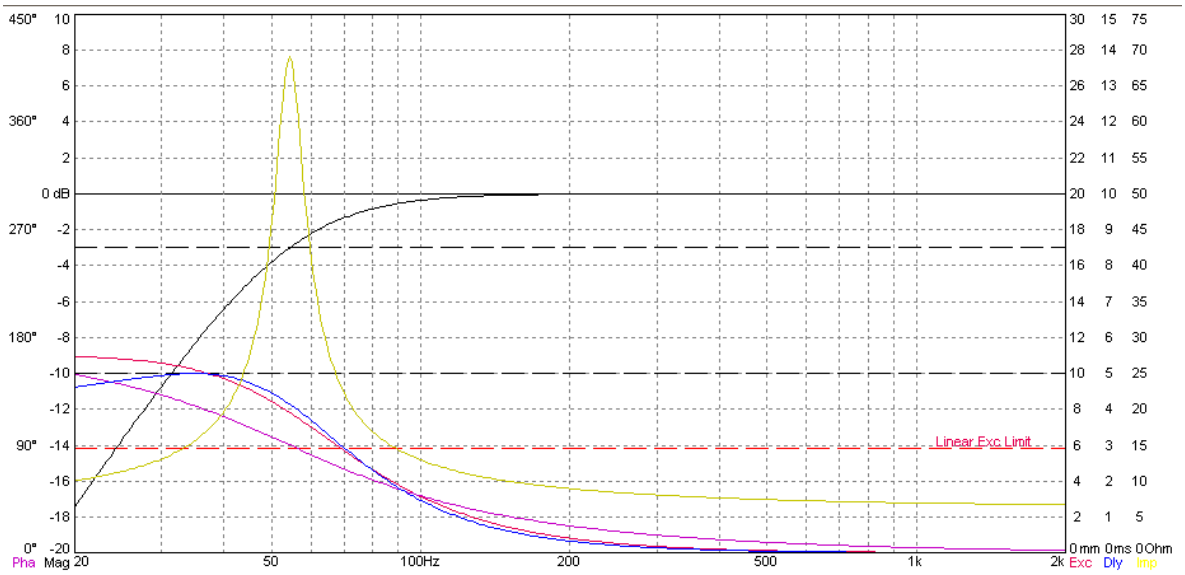


Figure 5.3: Scanspeak 22W/8534G00 Discovery Qts=.70

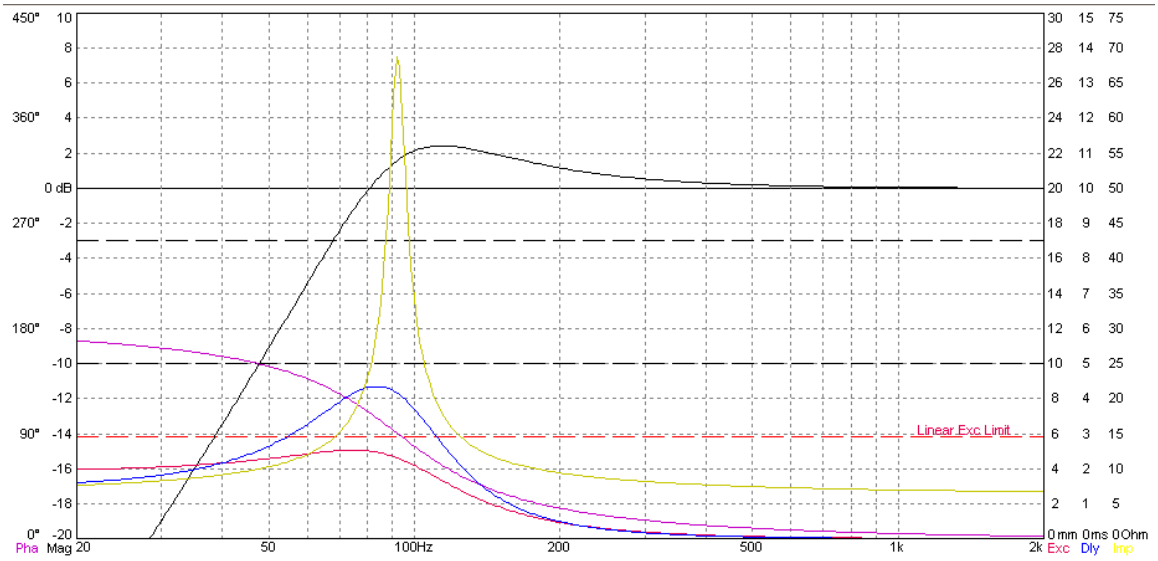


Figure 5.4: Scanspeak 22W/8534G00 Discovery Qts=1.2

Mid Range Analysis & Selection

The midranges I considered for my speakers include the SB Acoustics SB12NRXF25-4, the Seas MU10RB-SL (H1658-04), the Scanspeak Discovery 10F/8424G 4”, and the Seas Prestige MCA12RC H1304. This driver needs to have a flat response from 500 Hz to at least 4k Hz in order to cover the vocal range and at least 3 octaves in order to prevent bandpass gain from the crossover. This driver also needs to be less than $100.

Driver	Diameter	Sensitivity	Rated Power Handling	SPL at rated power (at 1m)	Modeled bandwidth min XO to max XO)	Cost
SB Acoustics SB12NRXF25-4	4"	87	30	101.8	300-3000 Hz	$53
Seas Prestige MU10RB-SL H1658-04	4"	84.7	40	100.7	200-4000 Hz	$58
Scanspeak Discovery 10F/8424G	4"	87	15	98.8	200-4000 Hz	$101
Seas Prestige MCA12RC H1304	4.5"	86	110	106	400-5000 Hz	$80

Mid Range #1 -SB Acoustics SB12NRXF25-4

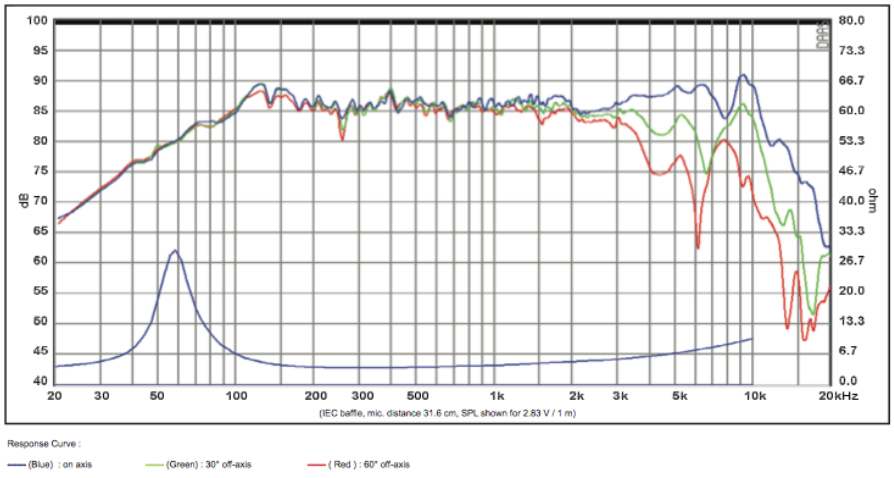


Figure 6.2 through 6.4 below shows the box response with a different Qtc of the SB Acoustics SB12NRXF25. This is a 4” woofer that costs $53. The bandwidth is 300-3000 Hz. This would not cover the full vocal range (4000 Hz). See the appendix for other specifications.

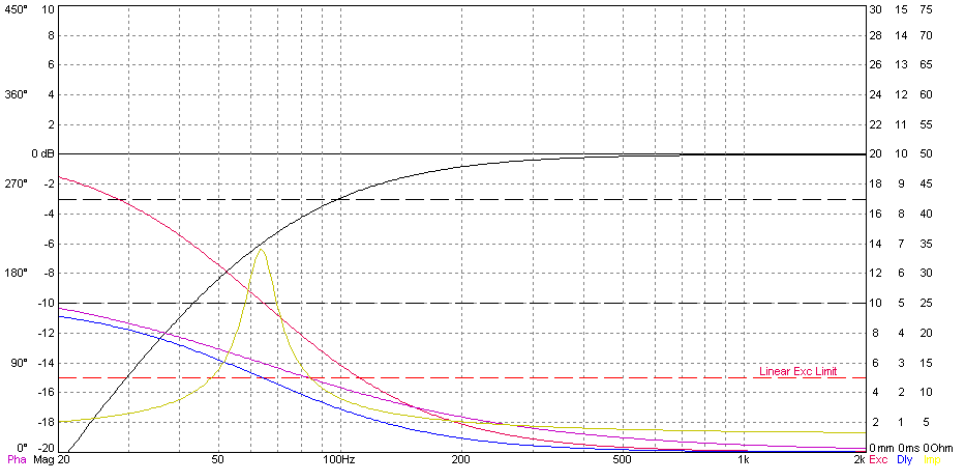


Figure 6.2: SB Acoustics SB12NRXF25 Qts=.5

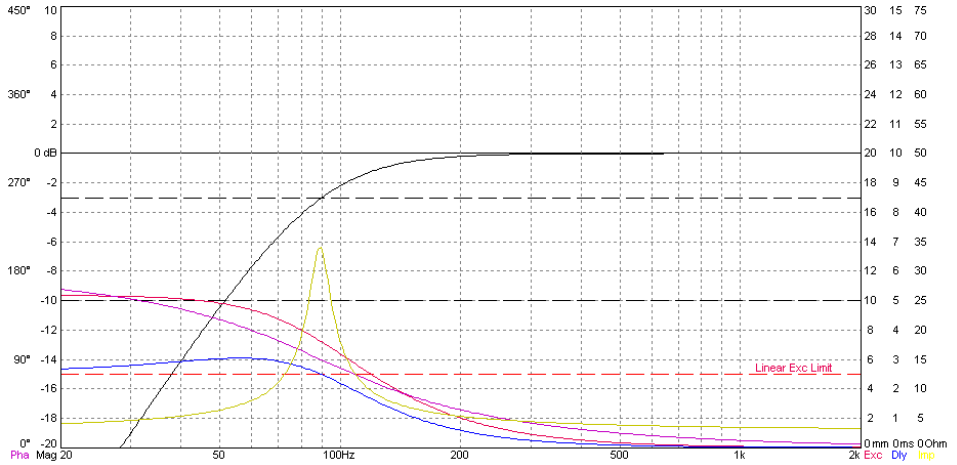


Figure 6.3: SB Acoustics SB12NRXF25 Qts=.7

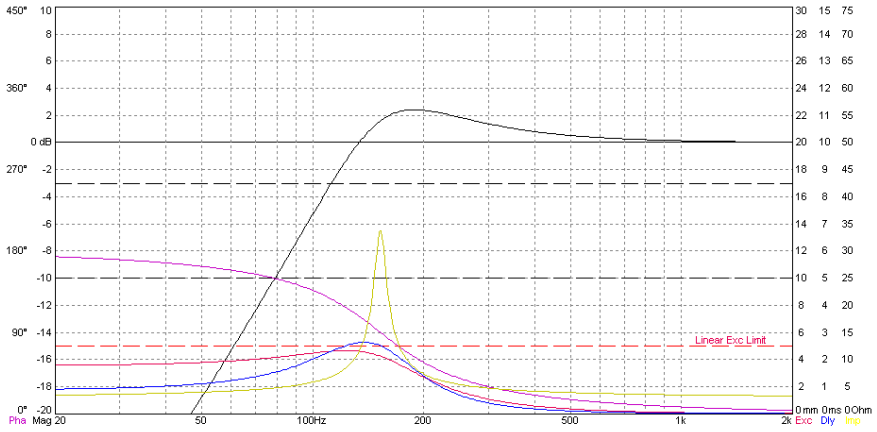


Figure 6.4: SB Acoustics SB12NRXF25 Qts=1.2

Mid Range #2 – Seas MU10RB-SL (H1658-04) 4" Woven Poly Cone Midrange

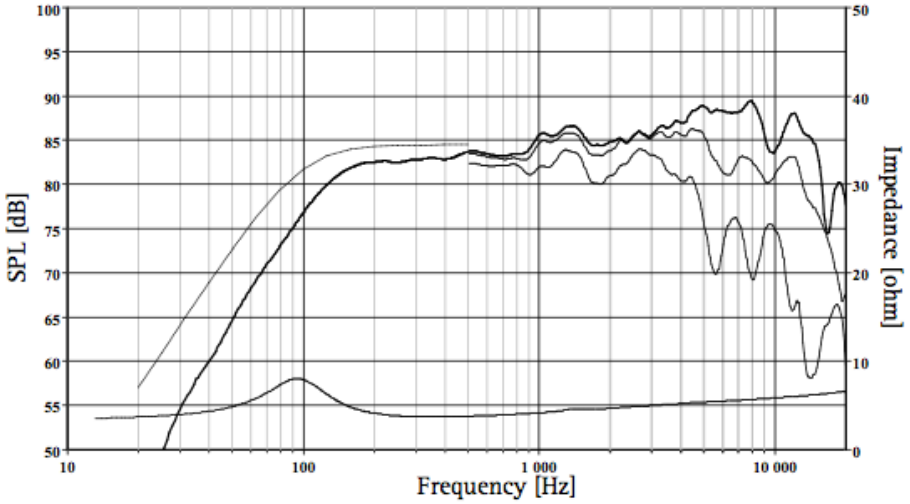


Figure 7.2 through 7.4 below shows the box response with a different Qtc of the – Seas MU10RB-SL (H1658-04). This is a 4" woofer that costs $58. The bandwidth is 200-4000 Hz. This driver is a good potential choice because of its low price and bandwidth. I can cross it over at 500Hz and 4000 Hz, for a total of 3 octaves of coverage. However the off-axis response starts to get weird at 1 kHz.

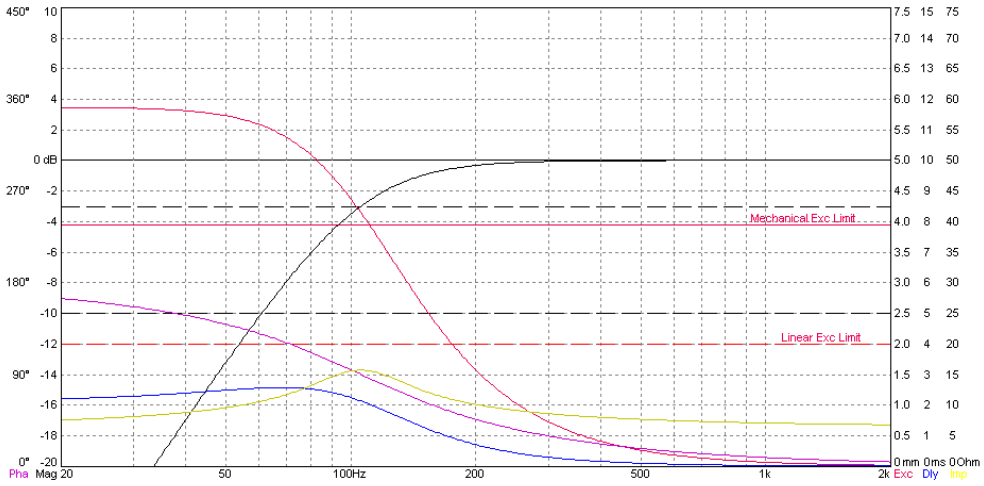


Figure 7.2: – Seas MU10RB-SL (H1658-04) Qts=.5

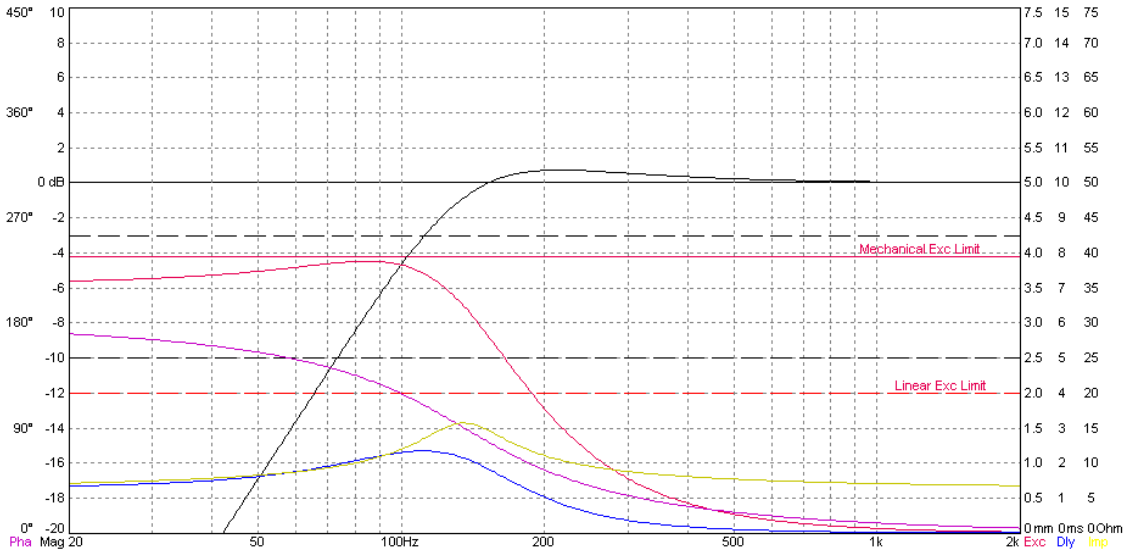


Figure 7.3: – Seas MU10RB-SL (H1658-04) Qts=.7

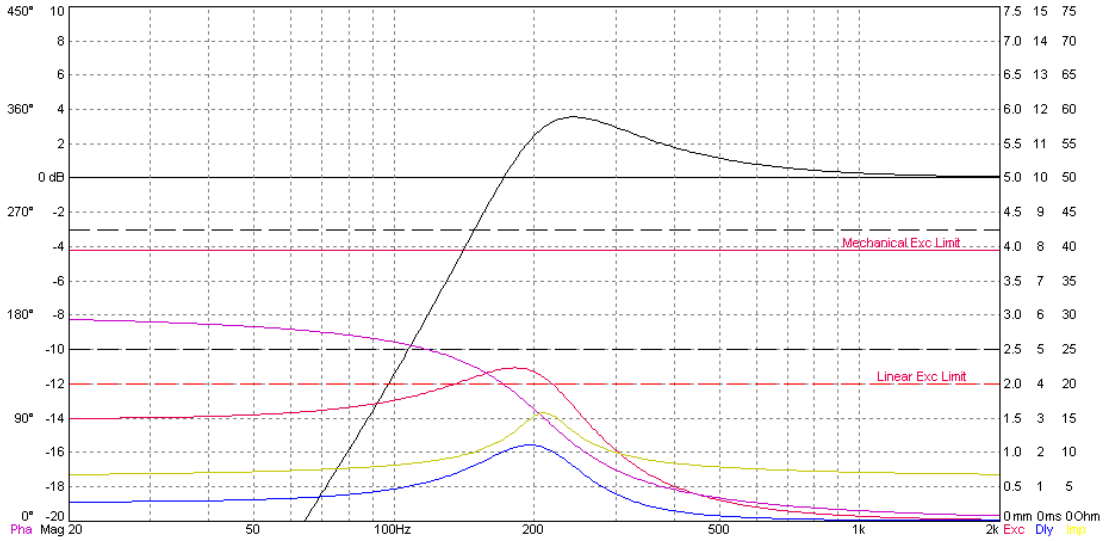


Figure 7.4: – Seas MU10RB-SL (H1658-04) Qts=1.2

Mid Range #3 – Scanspeak Discovery 10F/8424G 4"

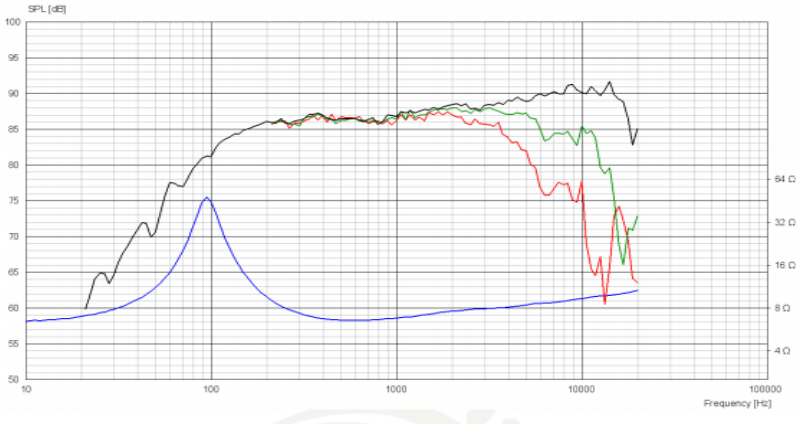


Figure 8.2 through 8.4 below shows the box response with a different Qtc of the – Scanspeak Discovery 10F/8424G. This is a 4" woofer that costs $101. The bandwidth is 200-4000 Hz. This driver is a good potential choice because of its fairly flat response and bandwidth. I can cross it over at 500Hz and 4000 Hz, for a total of 3 octaves of coverage. However it is the most expensive of the drivers I looked at. It costs $20 more than the next cheapest and offers no superior features2

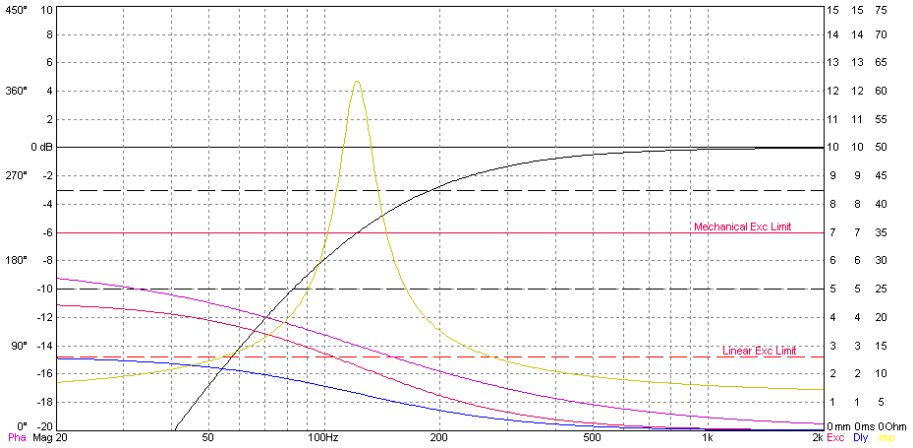


Figure 8.2: – Scanspeak Discovery 10F/8424G) Qts=.5

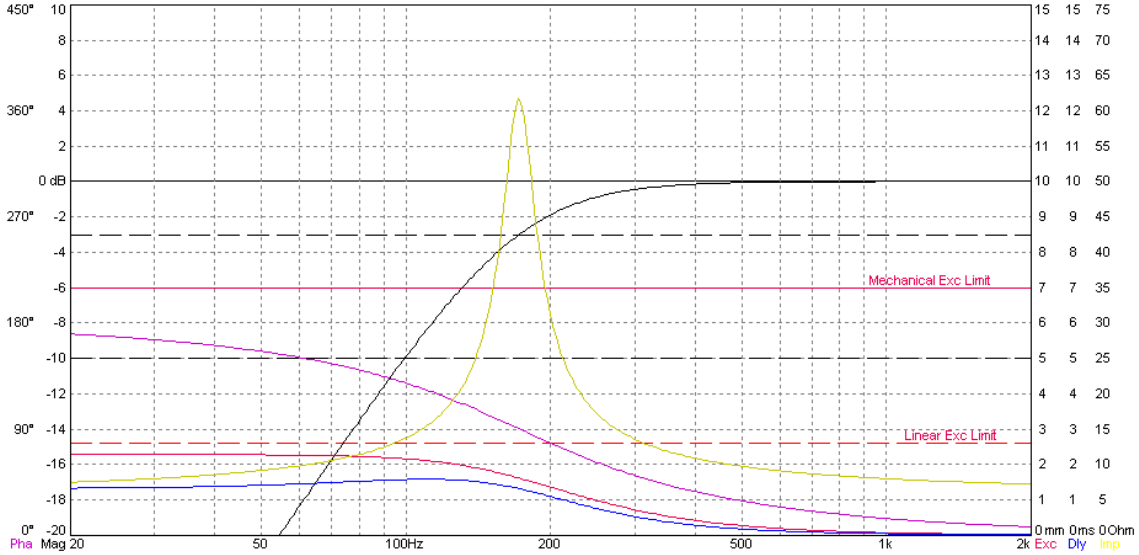


Figure 8.3: – Scanspeak Discovery 10F/8424G) Qts=.7

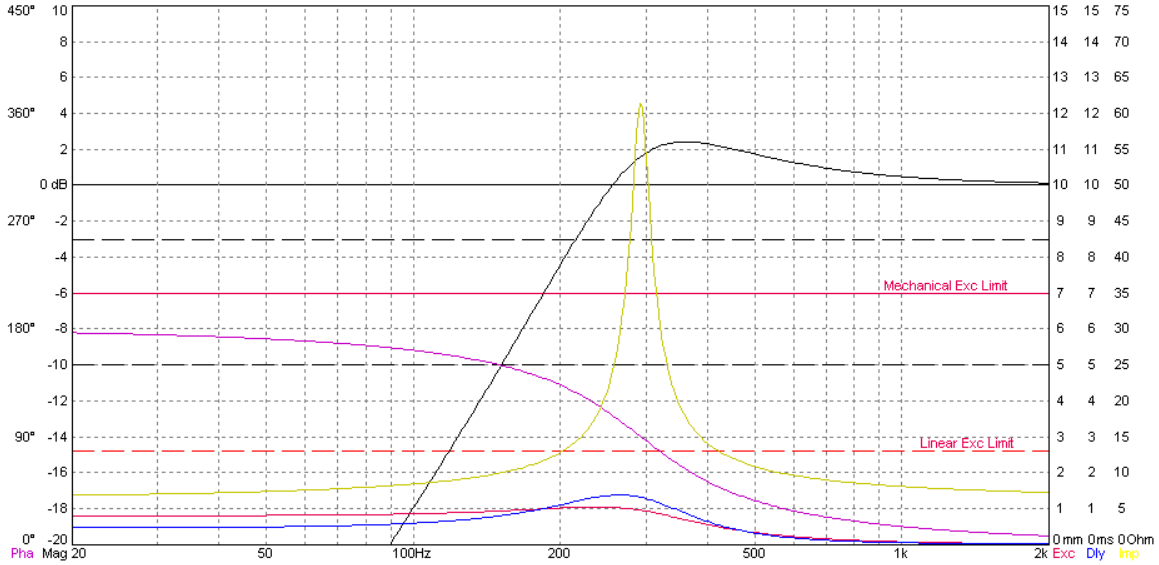


Figure 8.4: – Scanspeak Discovery 10F/8424G) Qts=1.2

Mid Range #4 – Seas Prestige MCA12RC H1304

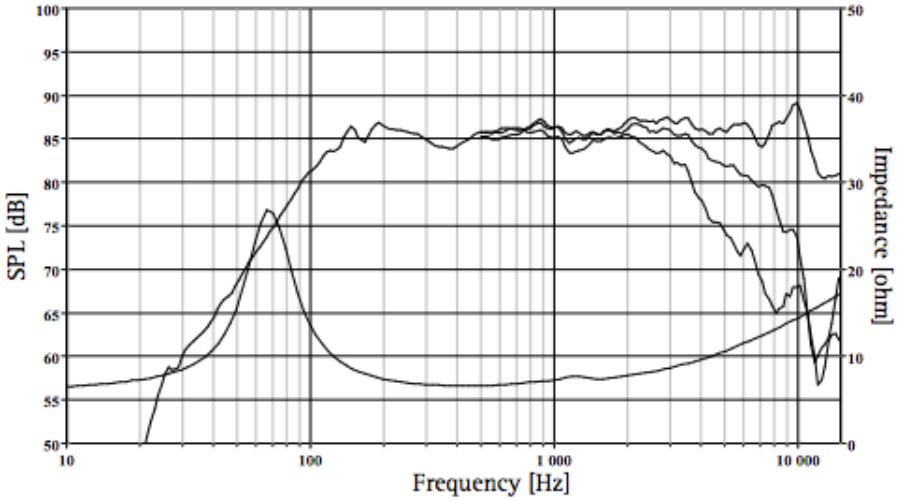


Figure 9.2 through 9.4 below shows the box response with a different Qtc of the Seas Prestige MCA12RC H1304. This is a 4.5" woofer that costs $80. The bandwidth is 200-5000 Hz. This driver has a good flat response and a good bandwidth. The off axis response in the bandwidth I would use is the best of the drivers I considered.

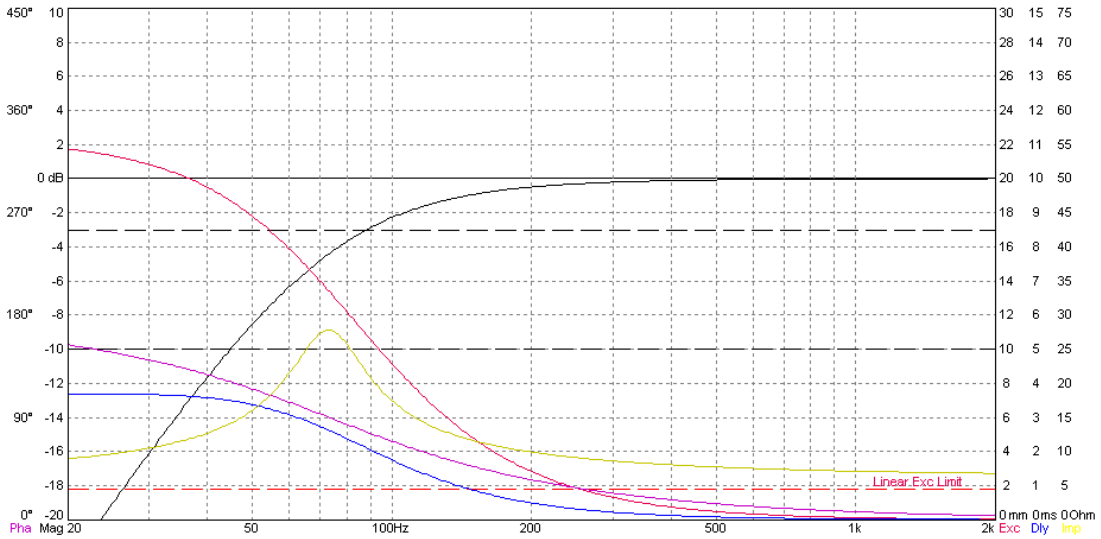


Figure 9.2: – Seas Prestige MCA12RC H1304 Qts=.5

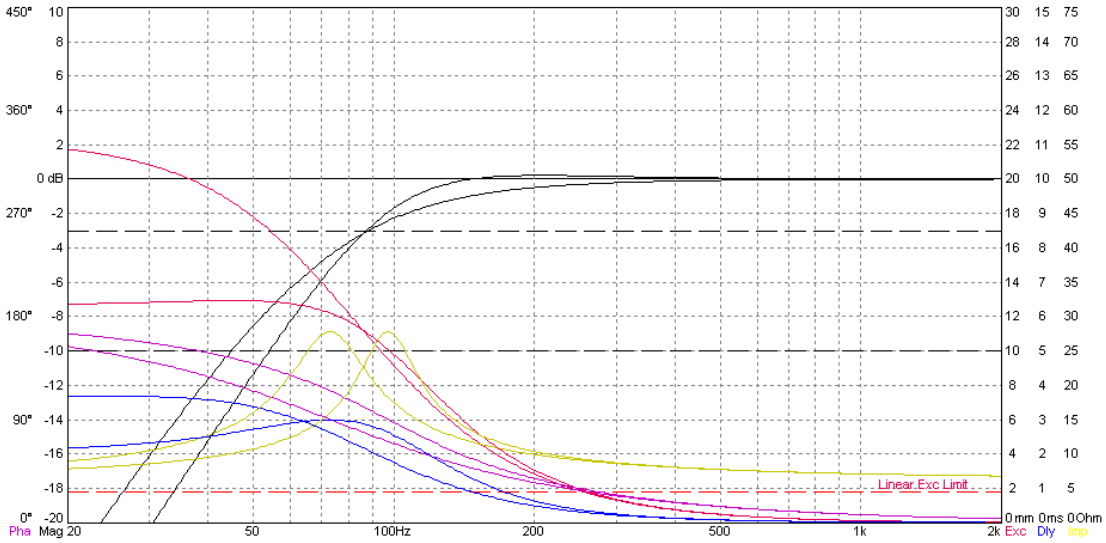


Figure 9.3: – Seas Prestige MCA12RC H1304 Qts=.7

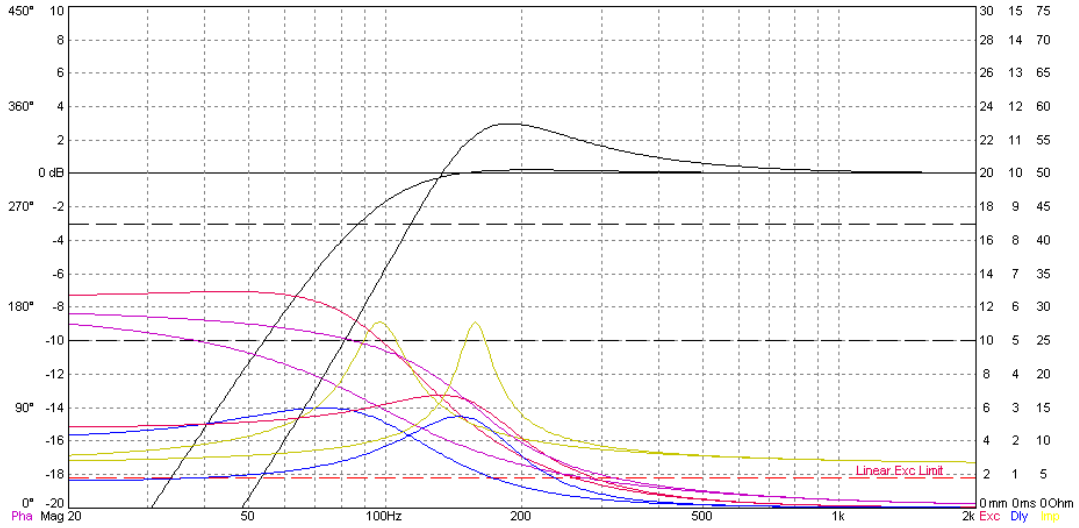
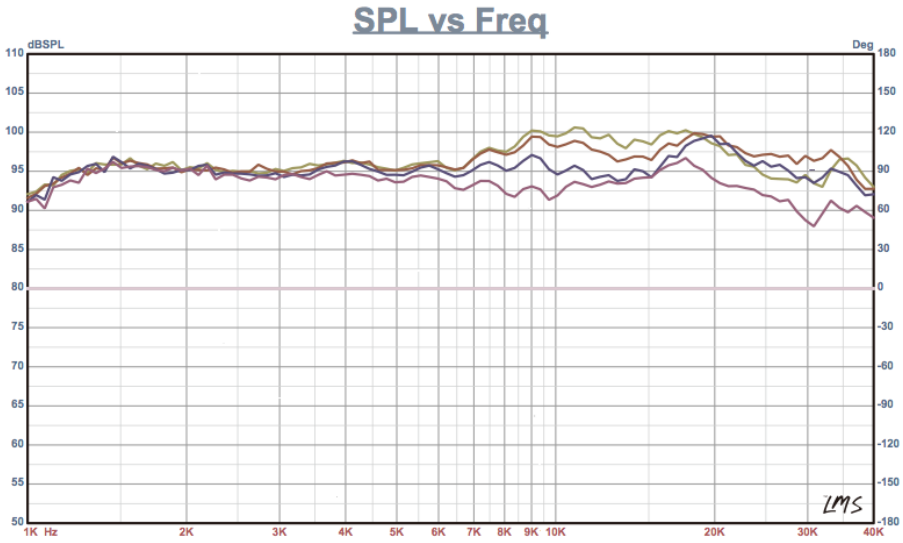


Figure 9.4: – Seas Prestige MCA12RC H1304 Qts=1.2

Tweeter Analysis & Selection

I am interested in using a ribbon tweeter in my speaker design. The have a low fatiguing and desirable, warm sound. My options were fairly limited due to the $150+ price range of most of the available ribbon tweeters. The ribbon tweeters I seriously considered were the Fountek NEOCD2.0, the Fountek NEOX2.0, and the Bohlender Graebener Neo3-PDRW Planar Tweeter.

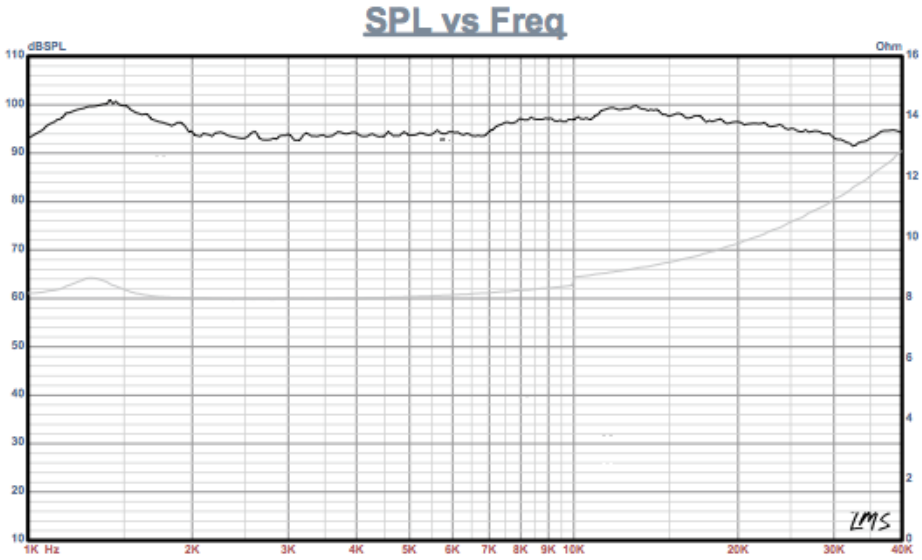
Tweeter #1 – Fountek NEOCD2.0m



horizontal diffusion: on-axis, 15 degree , 30 degree, 45 degree

This tweeter has a response down to 1200Hz with a recommended 3rd order crossover at 2500Hz. This would lead to me building a 3-way, as the woofers I am looking at only go up to 1 kHz. This tweeter costs about $120. See the appendix for other specifications.

Tweeter #2 – Fountek NEOX2.0



This tweeter also has a response down to 1200Hz with a recommended 2rd order crossover at 2300Hz. This tweeter costs about $90 (on sale). It is also a nice silver color. See the appendix for other specifications.

Tweeter #3 – Bohlender Graebener Neo3-PDRW Planar Tweeter

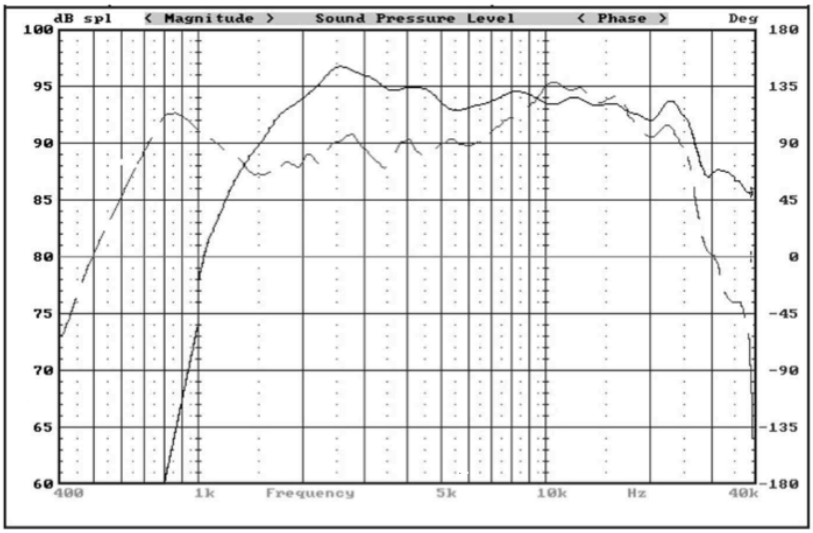


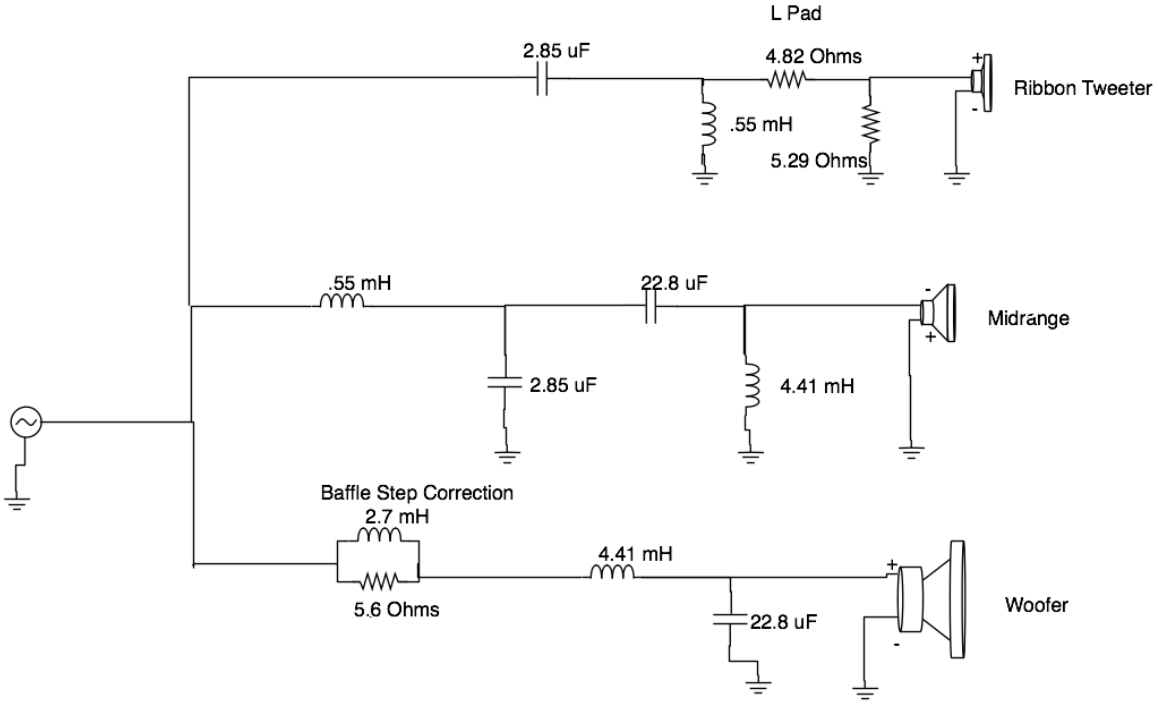
Fig. 1 NEO3PDR on-axis frequency response:
Solid – standard model, dash – dipole in a 9"x22" baffle

While this tweeter looked very interesting, I decided against experimenting with this planar tweeter and wanted to go with something that I was more familiar with. This tweeter met all my requirements except that it was a strange type similar to that of a ribbon and I had not heard of it before started searching for tweeters. This is also a dipole, which is more than I wanted to deal with in this project.

Testing & Tuning

Initial Performance

My first test gave me a response with phase issues at the upper crossover point, poor bass response, and different output levels between each driver. The crossover I used was from an online calculator with an additional baffle step[8]. The crossover points were set to be at 500 Hz and 4 kHz. There was a -20 dB dip around 7 kHz. They weren't bad to listen to despite the frequency response, but there was much to be improved upon. My initial crossover schematic is shown below.



[8]LaLena, Michael. DIY Audio and Video, "3-Way Crossover Designer / Calculator.".

Enclosure Optimization

I designed my box too large on purpose, which ensured that there was room for my crossover to fit inside without negatively affecting the bass response and to ensure that I would not have too small of a box. The box did in fact turn out to be too big; the box had a lower Qts than I wanted. However, this problem was easily remedied by filling the cabinet with some blue board. It made the box smaller, which raised the Qts, allowing me to end up with a F3 of 50 Hz exactly.

I also added a 1 ½" sheet of fiberglass to both the mid and main enclosure to diffuse box reflections. This worked quite well.

Cross-over Tuning

My final crossover is very different from my initial. In my original was all 2^{nd} order crossovers with points centered at 500Hz and 4 kHz with the midrange polarity flipped. The first thing to address was the phase cancelation between the mid and tweeter. I flipped the mid back to normal and had to flip the woofer to stop all negative interactions.

Next I started trying to get a flatter response. This lead to me noticing it would be flatter if I crossed over at about 250Hz and 2.5 kHz. I moved all my crossover points and ended up with a very flat response. However, when I listened to them, vocals sounded strange and unpleasant. This is because the crossover was right in the middle of the vocal range and the drivers are relatively far apart. I went back and started over.

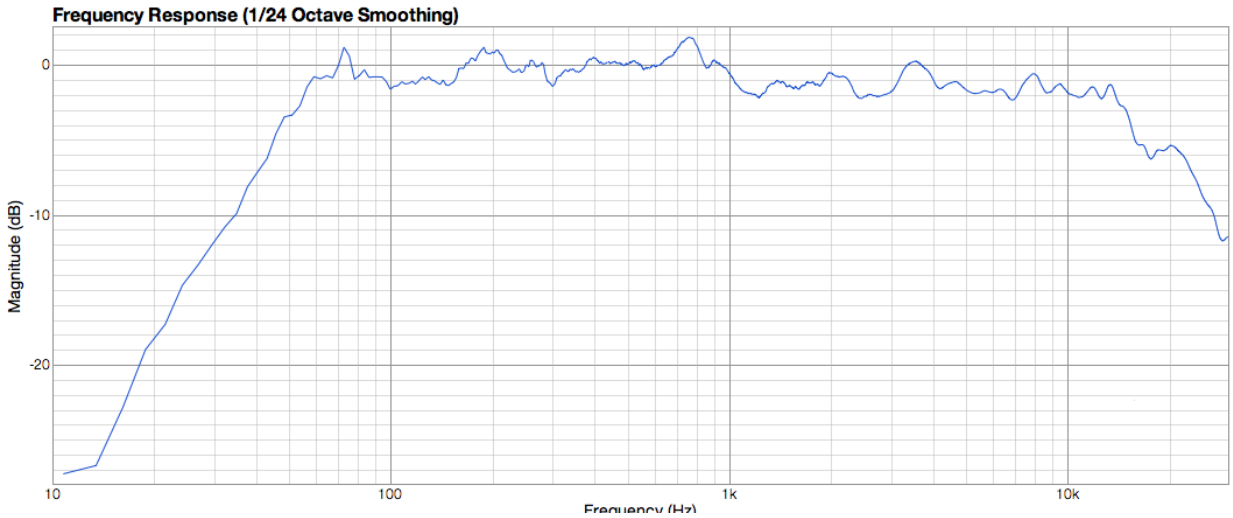
From this process I learned that the midrange responded better when I rolled it off lower at 300Hz rather than 500Hz. I kept that change, but moved the mid/tweeter crossover up to 4kHz. I then did a lot of value changing and experimenting with different changes. I

eventually got a response of mostly +/- 2dB, with about a –2 dB high-shelf starting at 1 kHz to reduce listening fatigue. This solved my vocal problem and sounded much better overall.

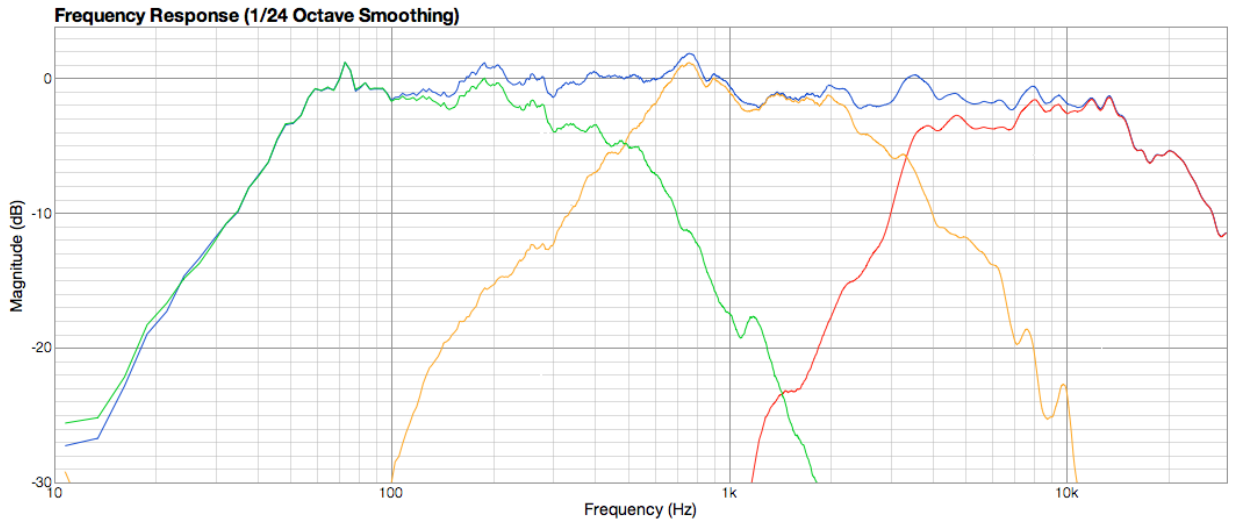
Final System Documentation

Final Testing Results

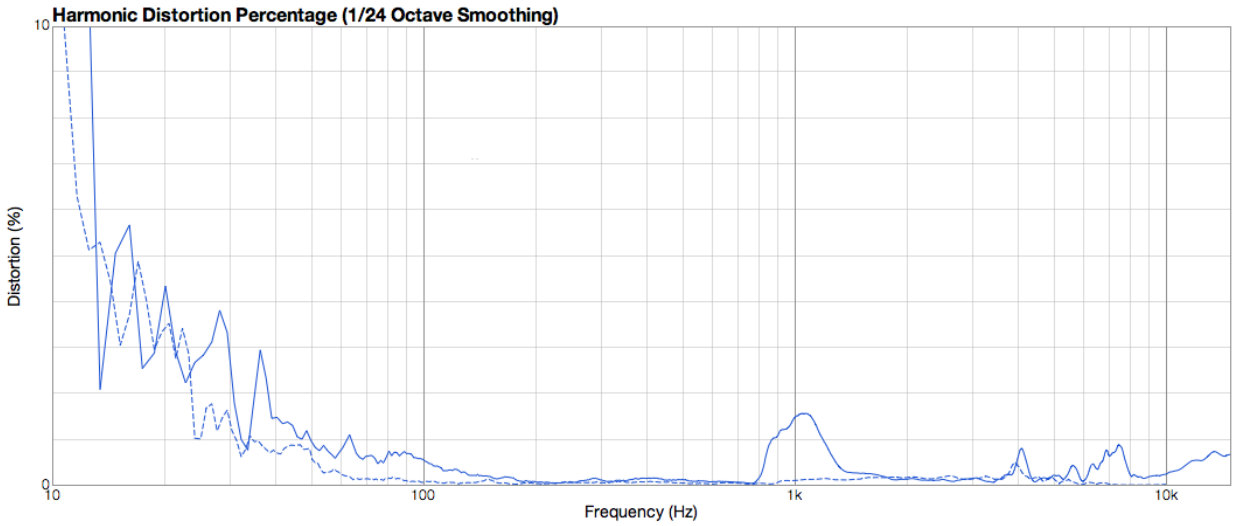
Below are my final testing results. Tests were done on an 8’ stand in McArdle Theatre. The microphone was positioned 14” away from the speaker, pointing slightly above the midpoint between the bottom of the ribbon and top of the midrange.



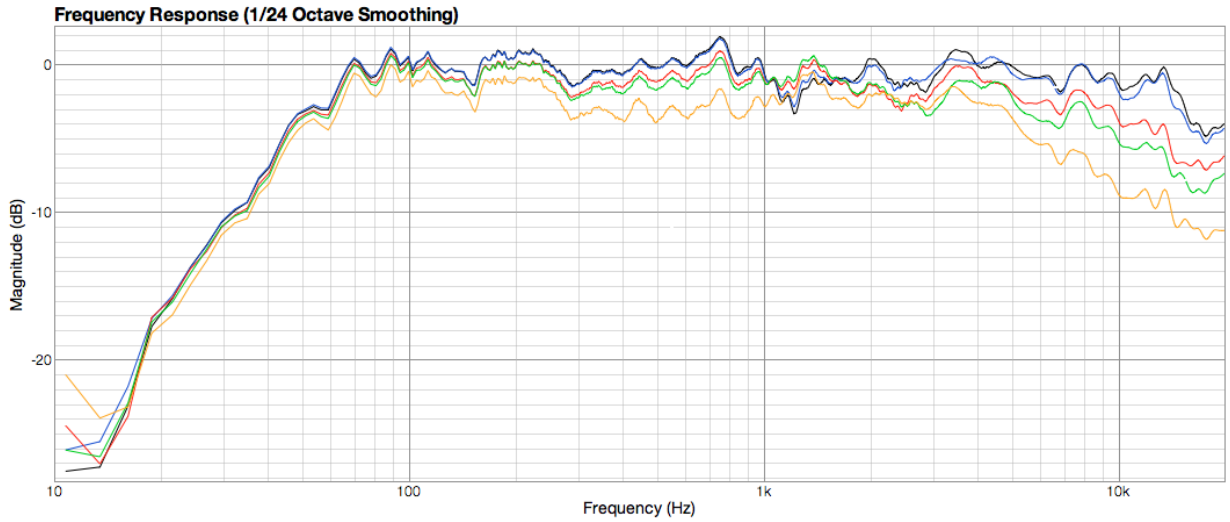
Frequency Response



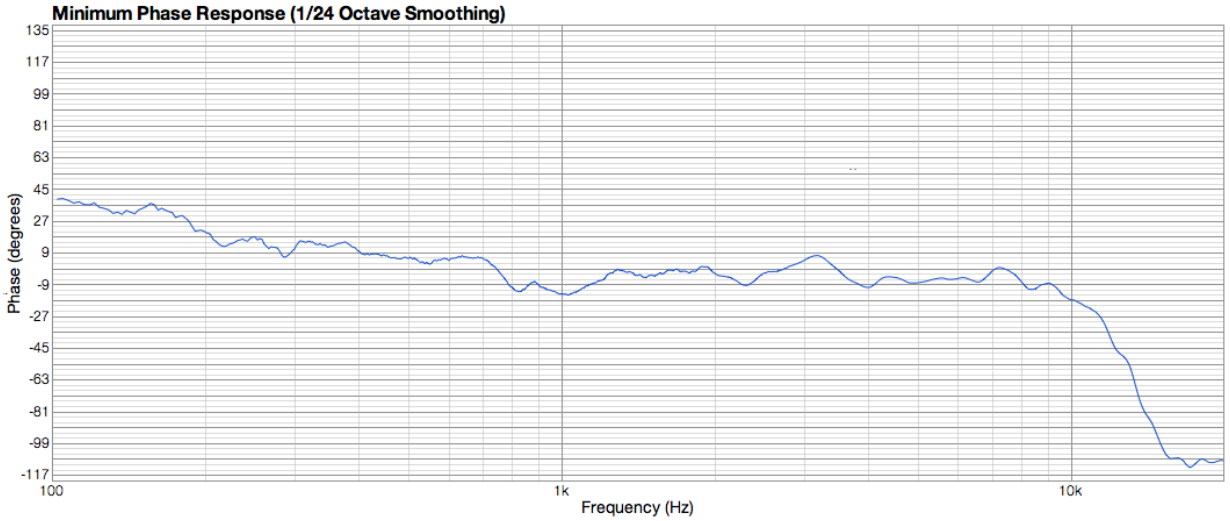
Individual Driver Frequency Response –
Green=Woofer – Orange=Midrange – Red=Tweeter



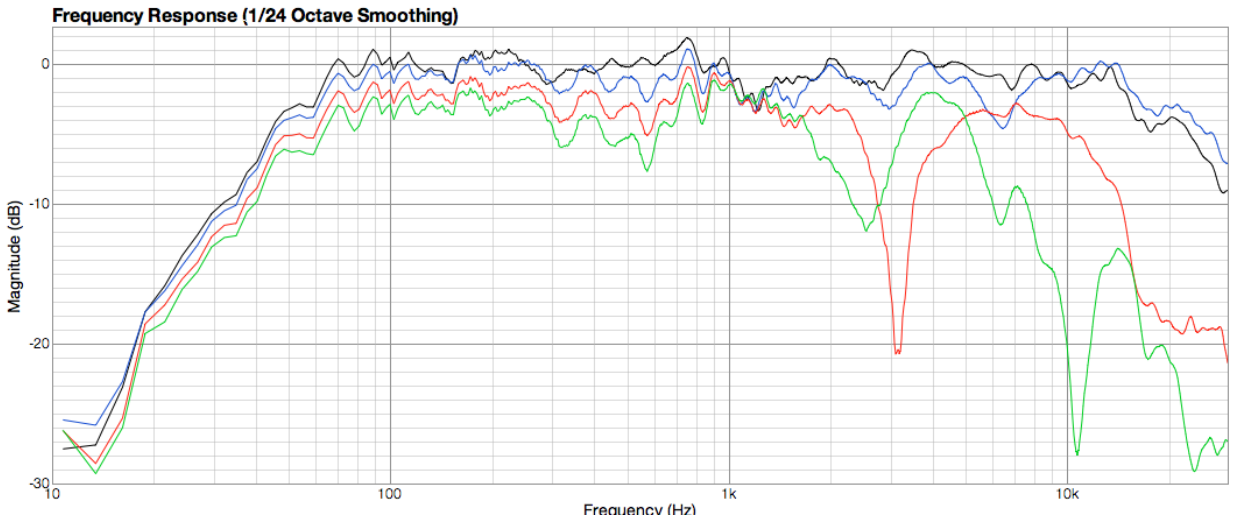
Harmonic Distortion %



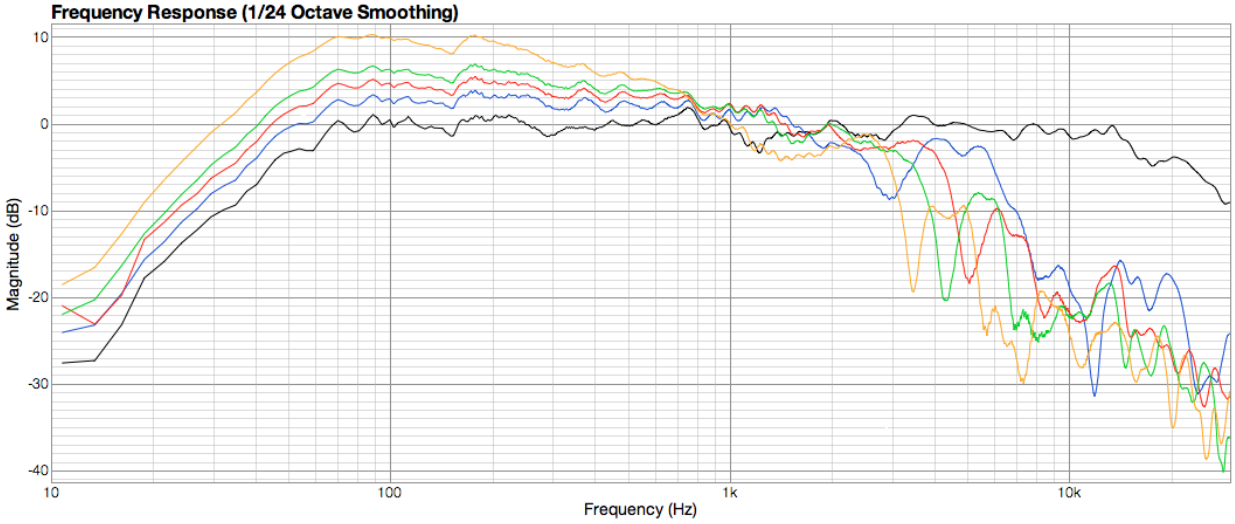
Horizontal Off-axis Response
Black= On-axis – Blue=15º - Red=30º – Green=45º - Orange=60º



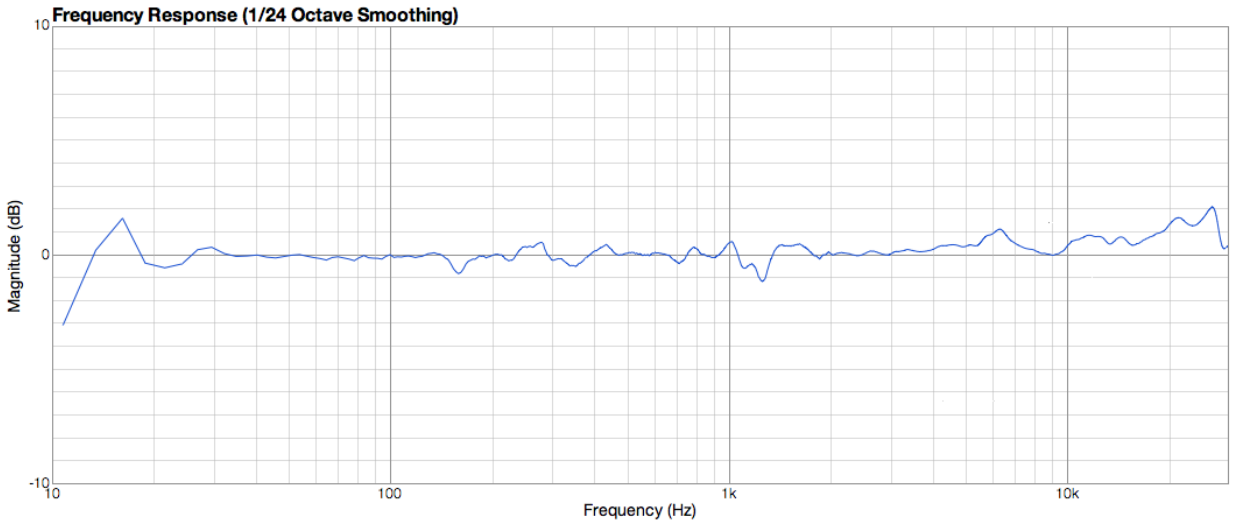
Phase Response



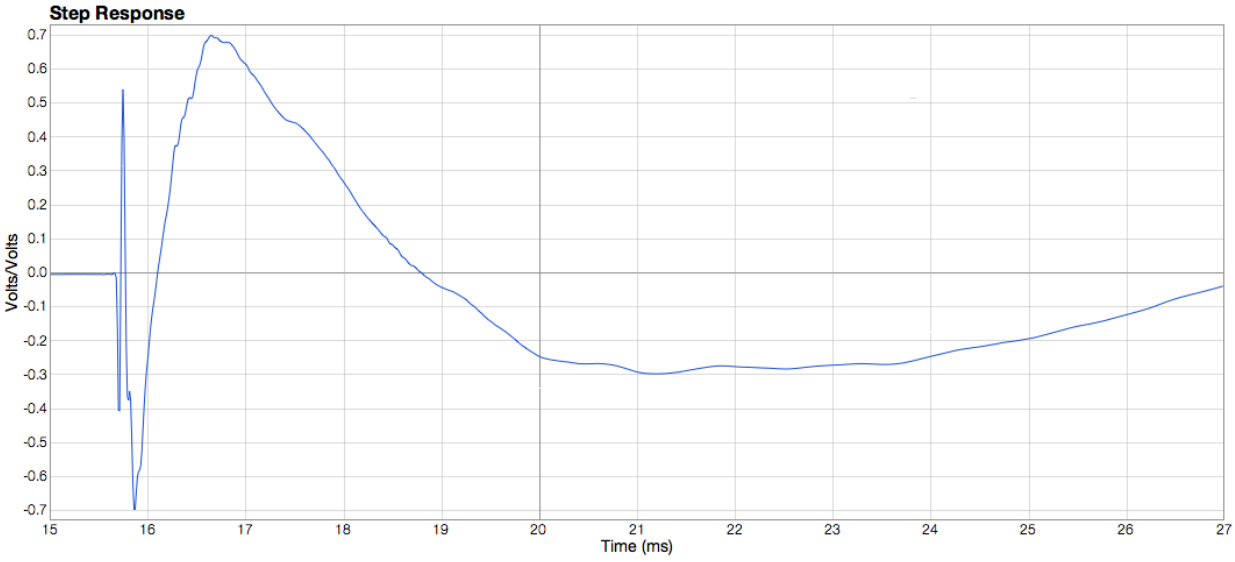
Above -Vertical Off-axis Response
Black= On-axis – Blue=15º - Red=30º – Green=45º



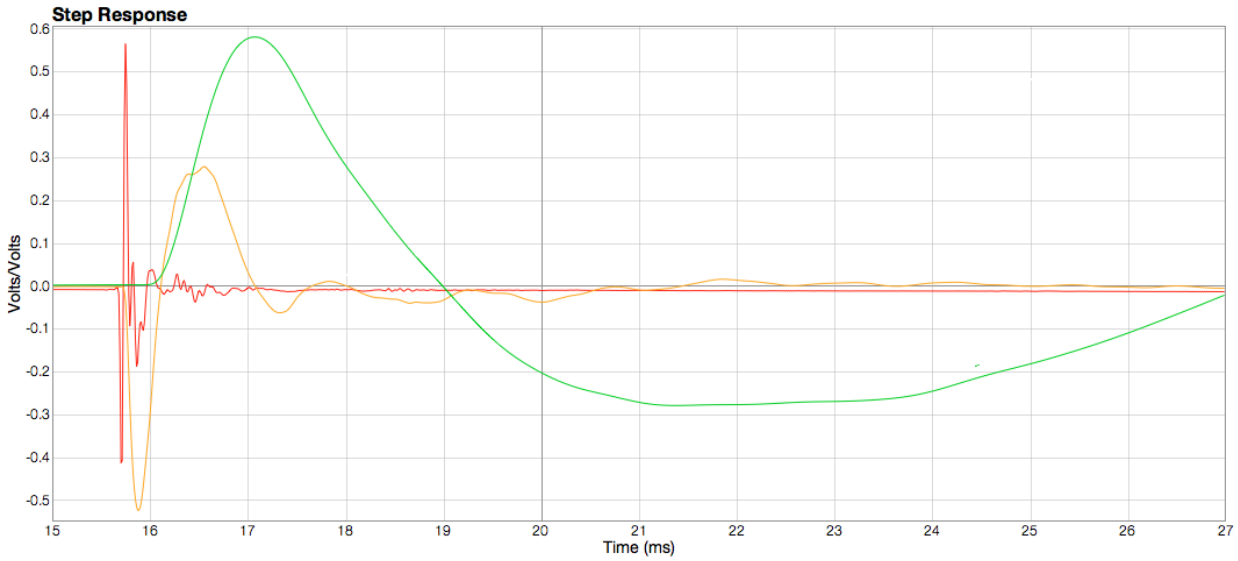
Below -Vertical Off-axis Response
Black= On-axis – Blue=15º - Red=30º – Green=45º - Orange=60º



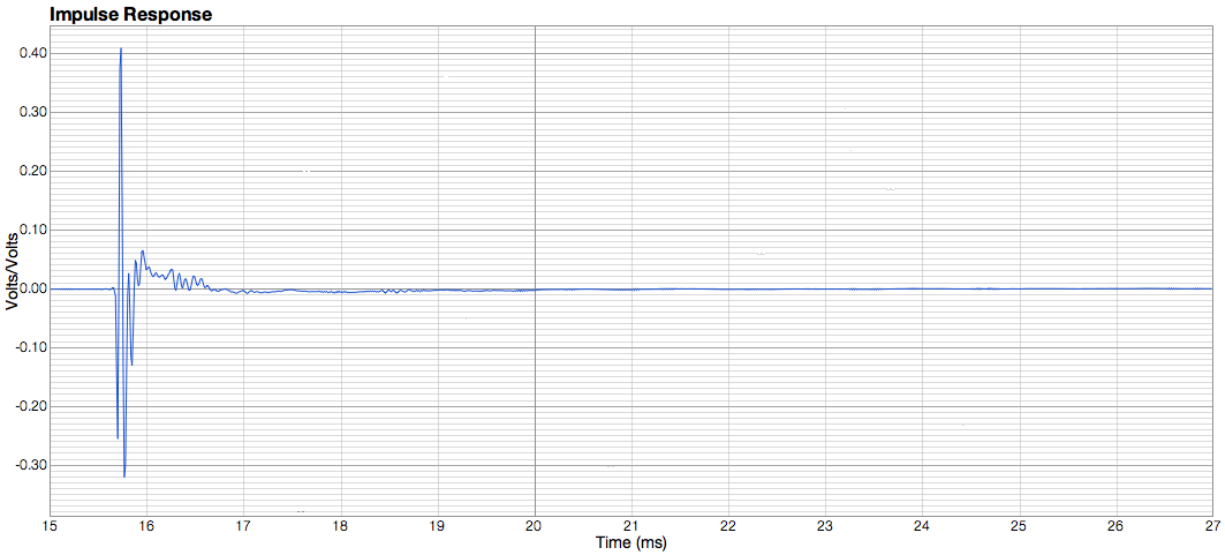
Left/Right Difference



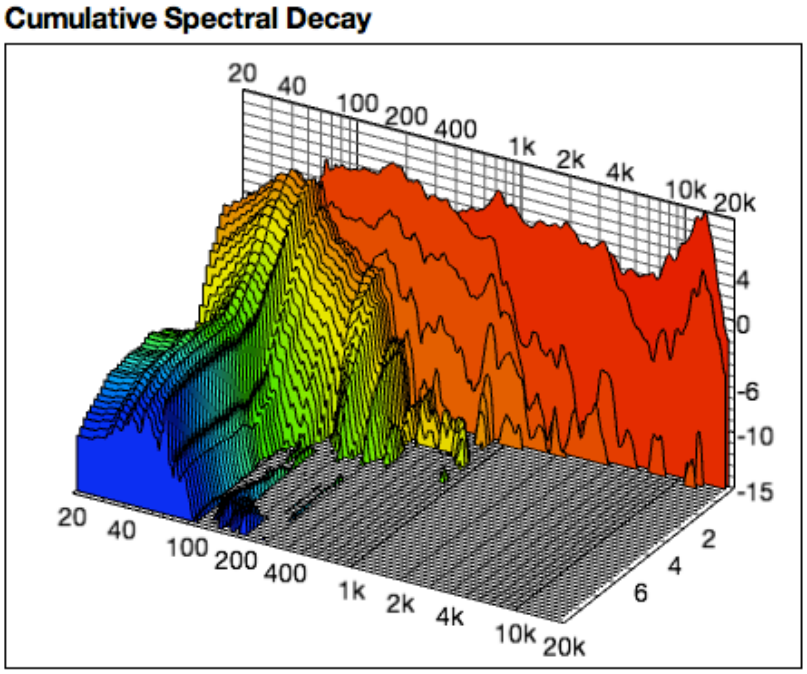
Step Response



Integrated Step Response

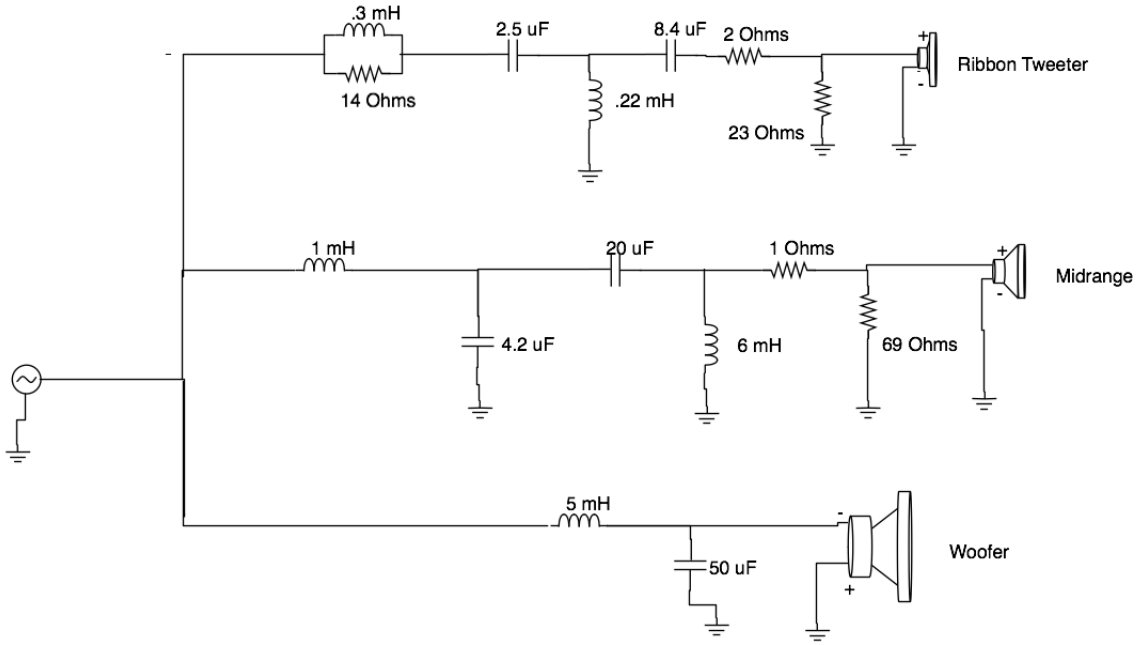


Impulse Response

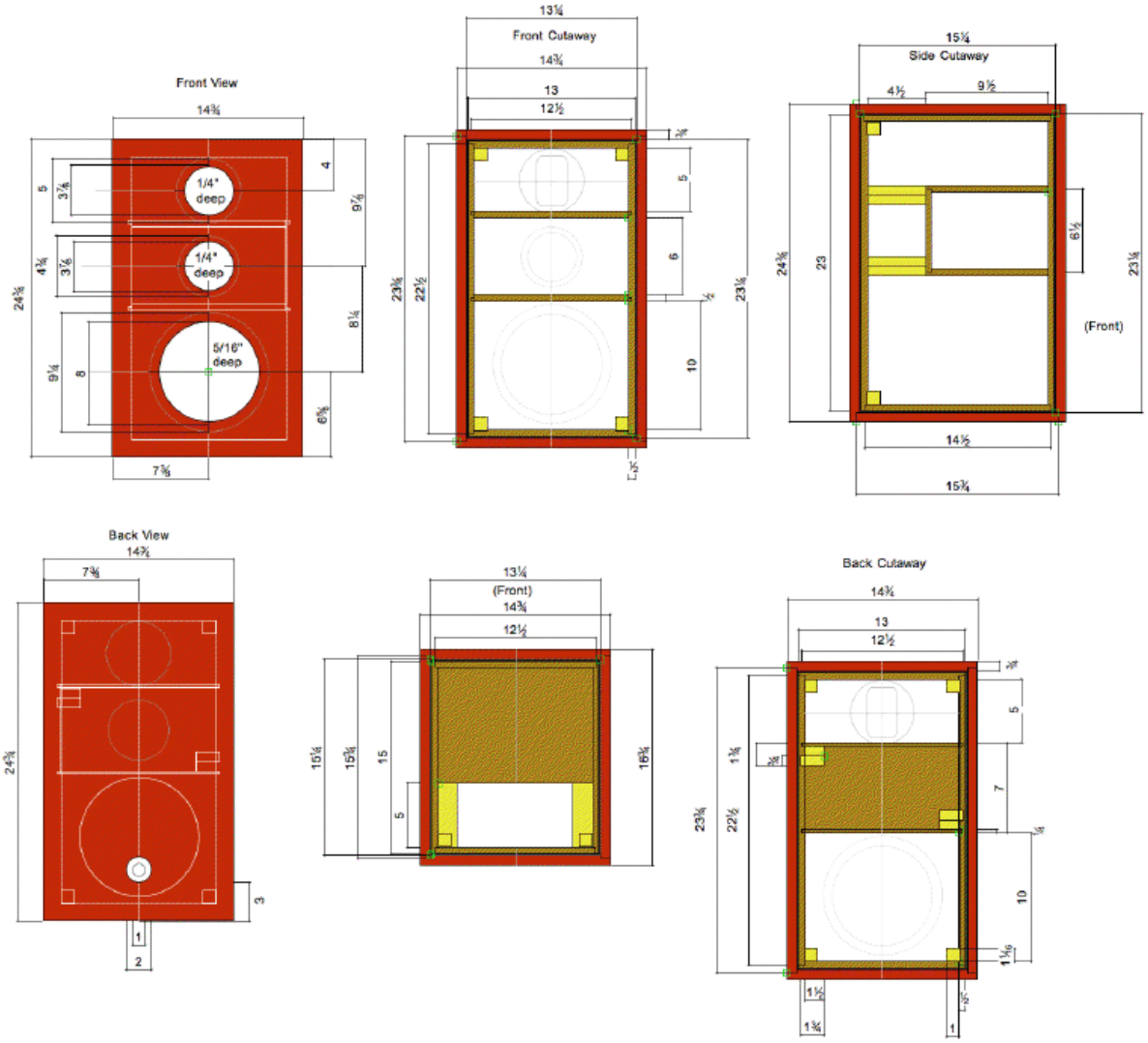


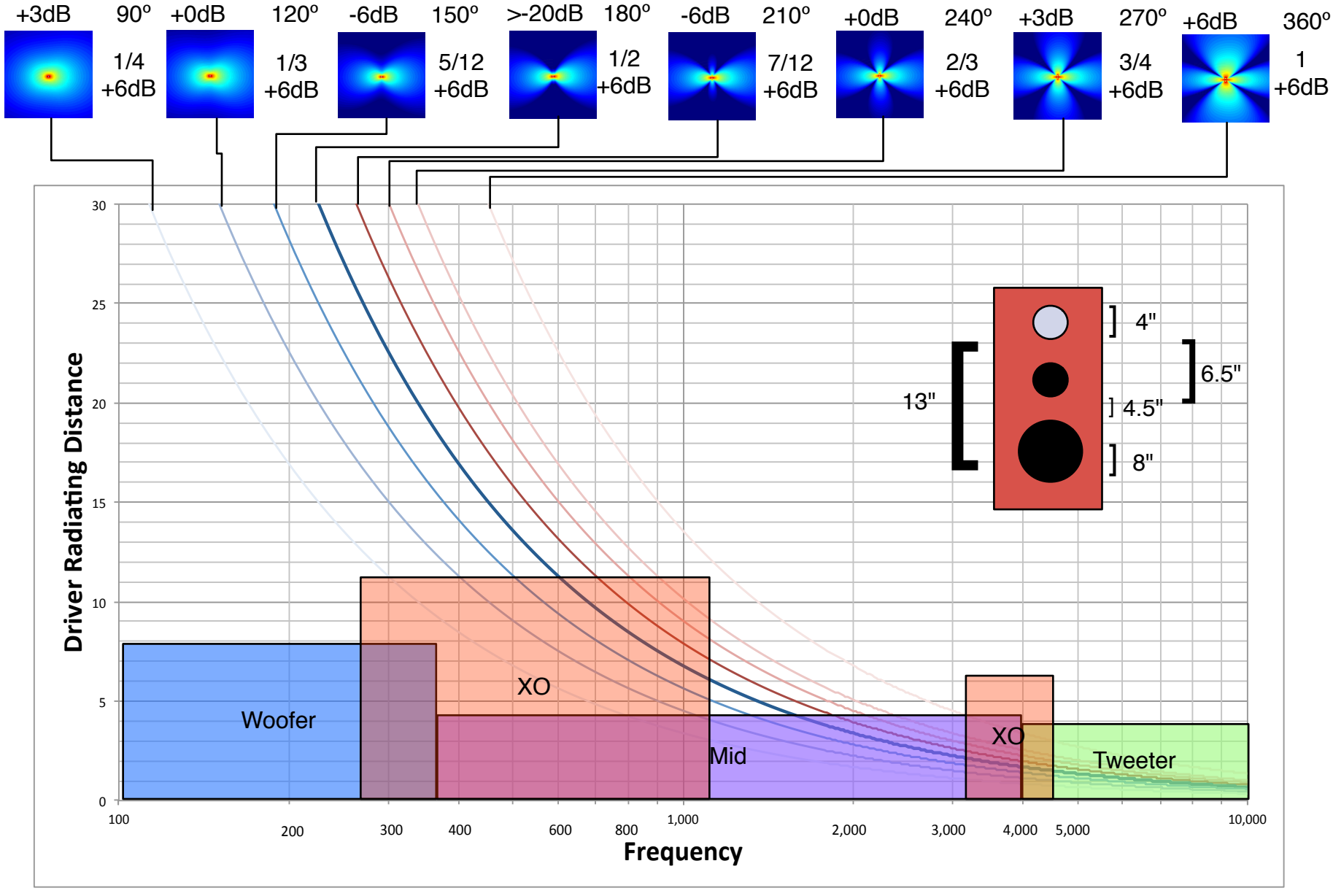
Waterfall Plot

Cross-over Schematic



As-built Drafting

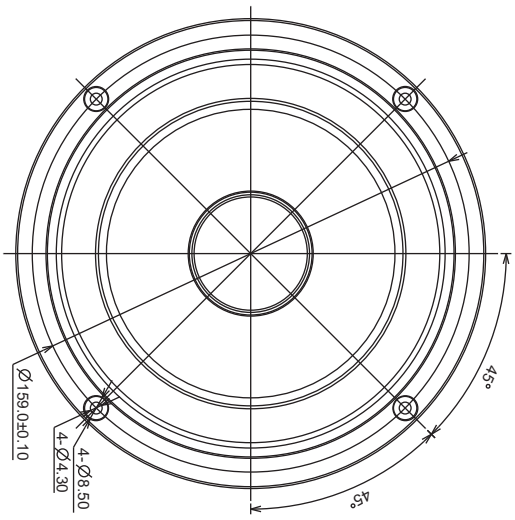


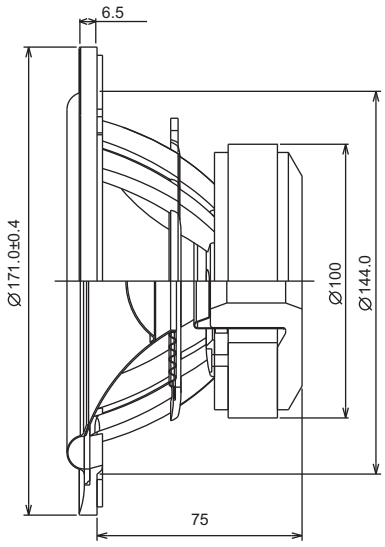


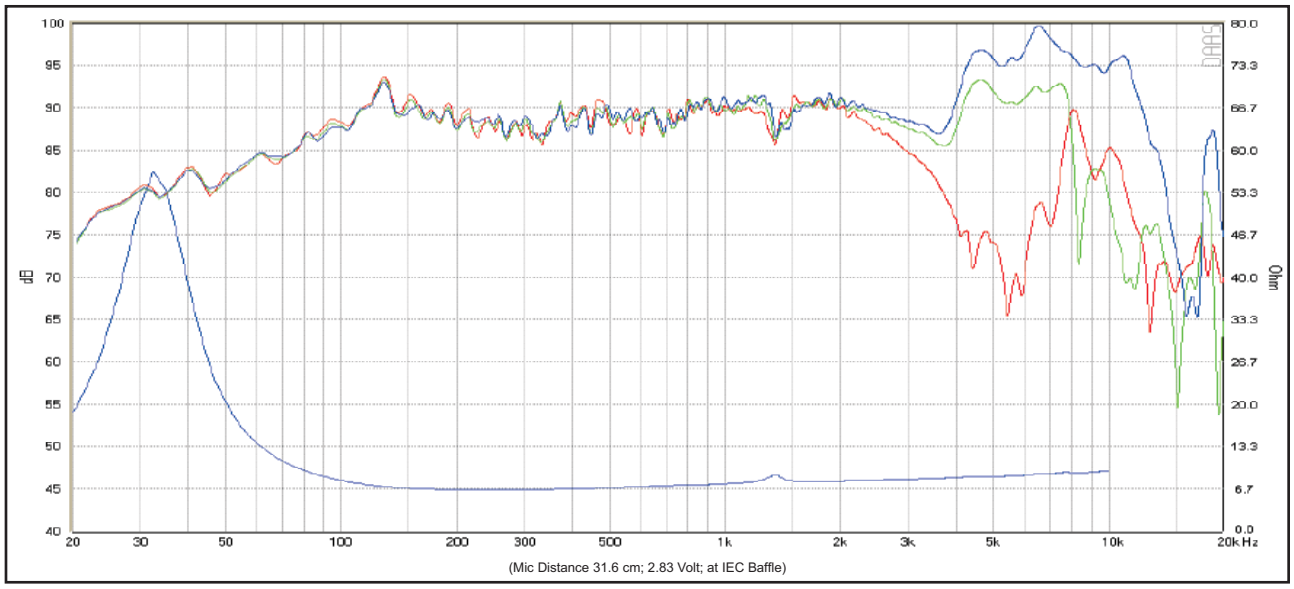
By: Renata Putzig

SB ACOUSTICS

6” SB17NRX35-8
(Preliminary Data)







Response Curve :

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

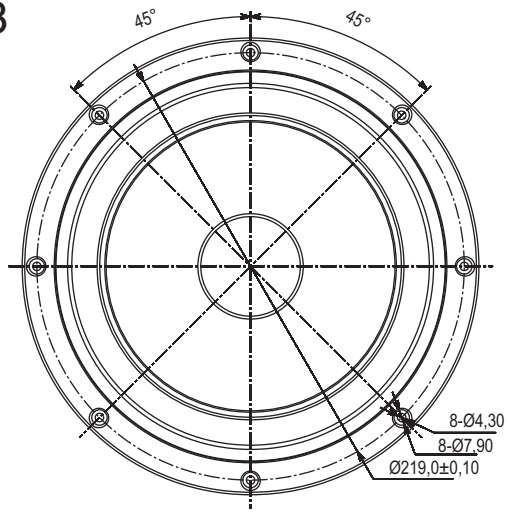
Specs :

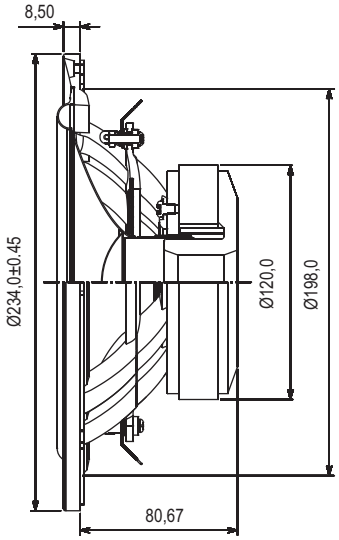
Nominal Impedance	8 Ω	Free air resonance, Fs	32 Hz
DC resistance, Re	5.7 Ω	Sensitivity (2.83 V/1m)	89 dB
Voice coil inductance, Le	0.15 mH	Mechanical Q-factor, Qms	5.0
Effective piston area, Sd	118 cm^2	Electrical Q-factor, Qes	0.36
Voice coil diameter	35.5 mm	Total Q-factor, Qts	0.34
Voice coil height	16 mm	Moving mass incl.air, md	11.0 g
Air gap height	5 mm	Force factor, Bl	5.9 Tm
Linear coil travel (p-p)	11 mm	Equivalent volume, Vas	44.5 liters
Magnetic flux density	1.0 T	Compliance, Cms	2.25 mm/N
Magnet weight	0.54 kg	Mechanical loss, Rm	0.44 kg/s
Net weight	1.56 kg	Rated power handling	60 watt

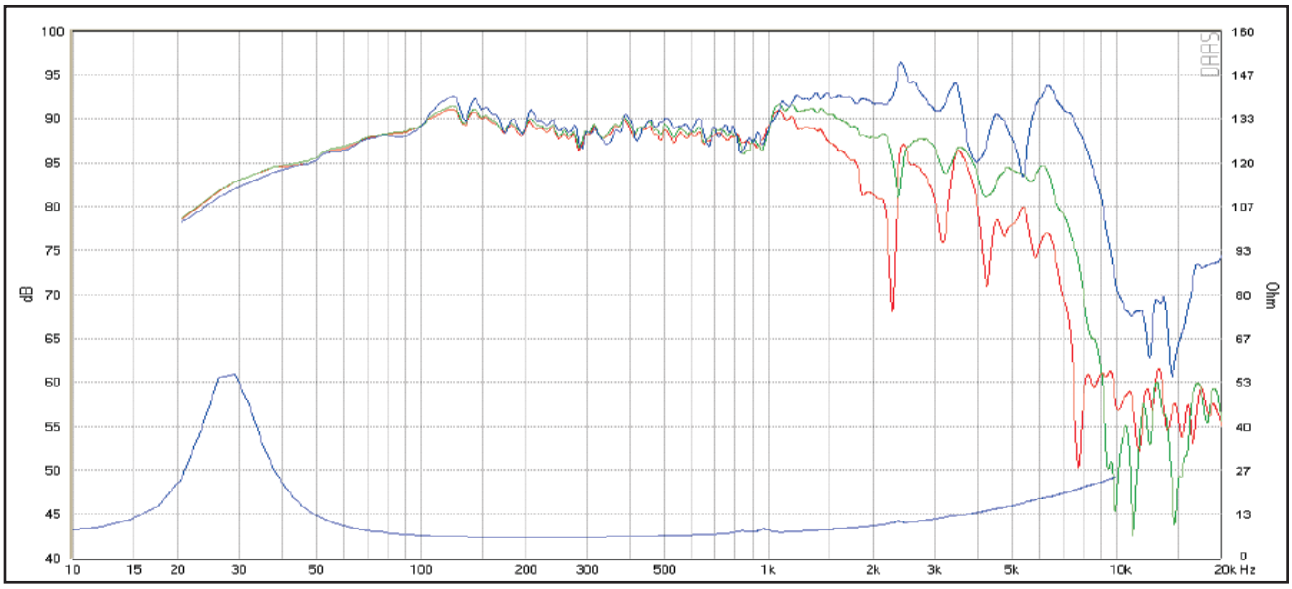
The parameter are measured on drive units that are broken in

SB ACOUSTICS

8” SB23NRXS45-8







Response Curve :

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

Specs :

Nominal Impedance	8 Ω	Free air resonance, Fs	27 Hz
DC resistance, Re	5.6 Ω	Sensitivity (2.83 V/1m)	88.5 dB
Voice coil inductance, Le	0.60 mH	Mechanical Q-factor, Qms	5.4
Effective piston area, Sd	216 cm^2	Electrical Q-factor, Qes	0.41
Voice coil diameter	45.5 mm	Total Q-factor, Qts	0.38
Voice coil height	19 mm	Moving mass incl.air, md	24.5 g
Air gap height	6 mm	Force factor, Bl	7.5 Tm
Linear coil travel (p-p)	13 mm	Equivalent volume, Vas	94 liters
Magnetic flux density	0.86 T	Compliance, Cms	1.42 mm/N
Magnet weight	0.8 kg	Mechanical loss, Rm	0.77 kg/s
Net weight	2.74 kg	Rated power handling	60 watt

The parameter are measured on drive units that are broken in

L16RN-SL
H1480

L16RN-SL is a 5” High Fidelity woofer with an injection moulded metal chassis, specially designed in cooperation with Linkwitz Labs in Corte Medera, California.

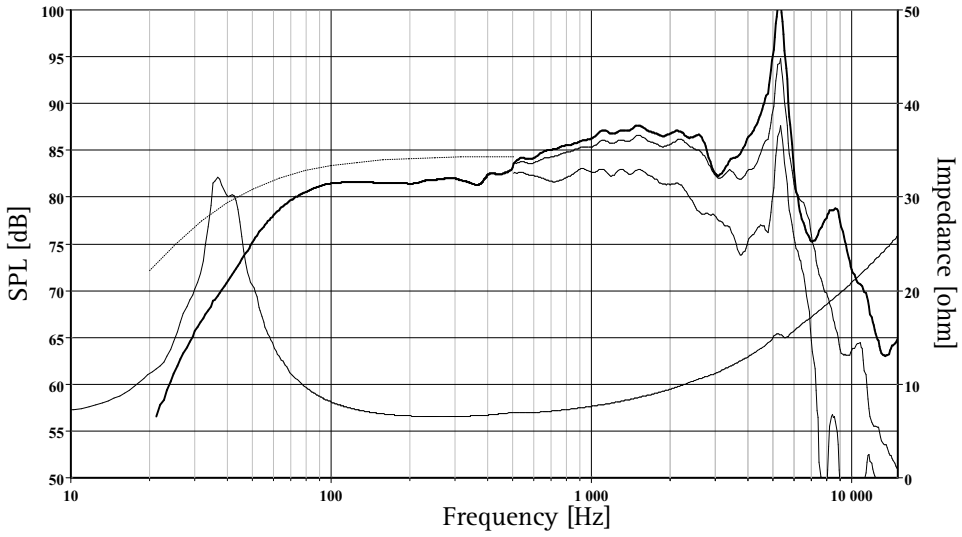
Stiff, yet light aluminum cone and low loss rubber surround show no sign of the familiar 500-1500 Hz cone edge resonance and distortion assosiated with soft cones.

A bumped back plate in the magnet system, together with the very long and light weight copper clad aluminum voice coil, allow extreme coil excursion with low distortion.

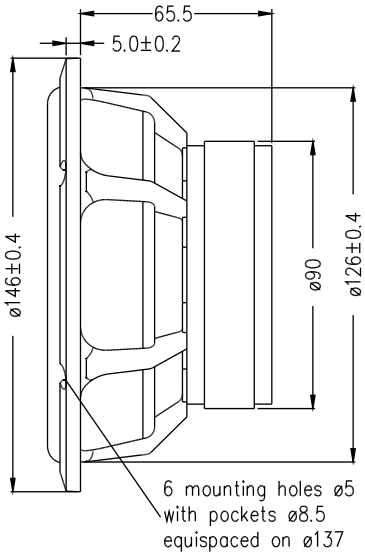
A heavy copper ring below the T-shaped pole piece, to reduce non linear and modulation distortion.

Extremely stiff and stable injection moulded metal basket, keeps the critical components in perfect alignment. Large windows in the basket both above and below the spider reduce sound reflection, air flow noise and cavity resonance to a minimum.

This driver uses Seas SpiderRing® technology.



The frequency responses above show measured free field sound pressure in 0, 30, and 60 degrees angle using a 10L closed box. Input 2.83 Vrms, microphone distance 0.5m, normalized to SPL 1m.The dotted line is a calculated response in infinite baffle based on the parameters given for this specific driver. The impedance is measured in free air without baffle using a 2V sine signal.



Nominal Impedance	8 Ohms	Voice Coil Resistance	6.0 Ohms
Recommended Frequency Range	45 - 2000 Hz	Voice Coil Inductance	0.64 mH
Short Term Power Handling *	250 W	Force Factor	6.1 N/A
Long Term Power Handling *	80 W	Free Air Resonance	37 Hz
Characteristic Sensitivity (2,83V, 1m)	84 dB	Moving Mass	14.7 g
Voice Coil Diameter	39 mm	Air Load Mass In IEC Baffle	0.62 g
Voice Coil Height	18 mm	Suspension Compliance	1.3 mm/N
Air Gap Height	6 mm	Suspension Mechanical Resistance	1.38 Ns/m
Linear Coil Travel (p-p)	12 mm	Effective Piston Area	104 cm²
Maximum Coil Travel (p-p)	22 mm	VAS	19 Litres
Magnetic Gap Flux Density	0.88T	QMS	2.48
Magnet Weight	0.42 kg	QES	0.55
Total Weight	1.40 kg	QTS	0.45

Nov 2011

*IEC 268-5

SEAS reserves the right to change technical data

RoHS compliant product

www.seas.no

AUDAX

LA PASSION DU HAUT-PARLEUR

HM210C0

BASS MIDRANGE

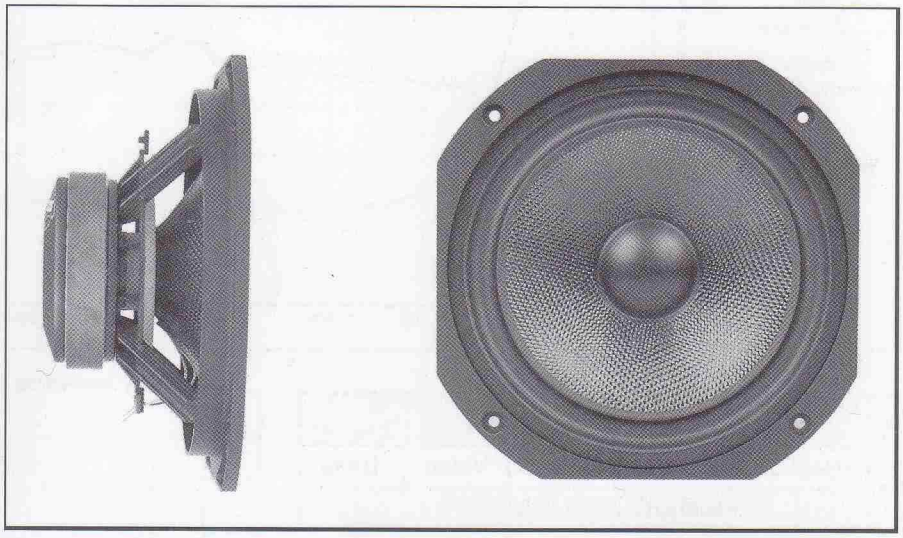
100982T

8" - CARBON FIBER CONE - 210 mm

REFERENCE SERIES

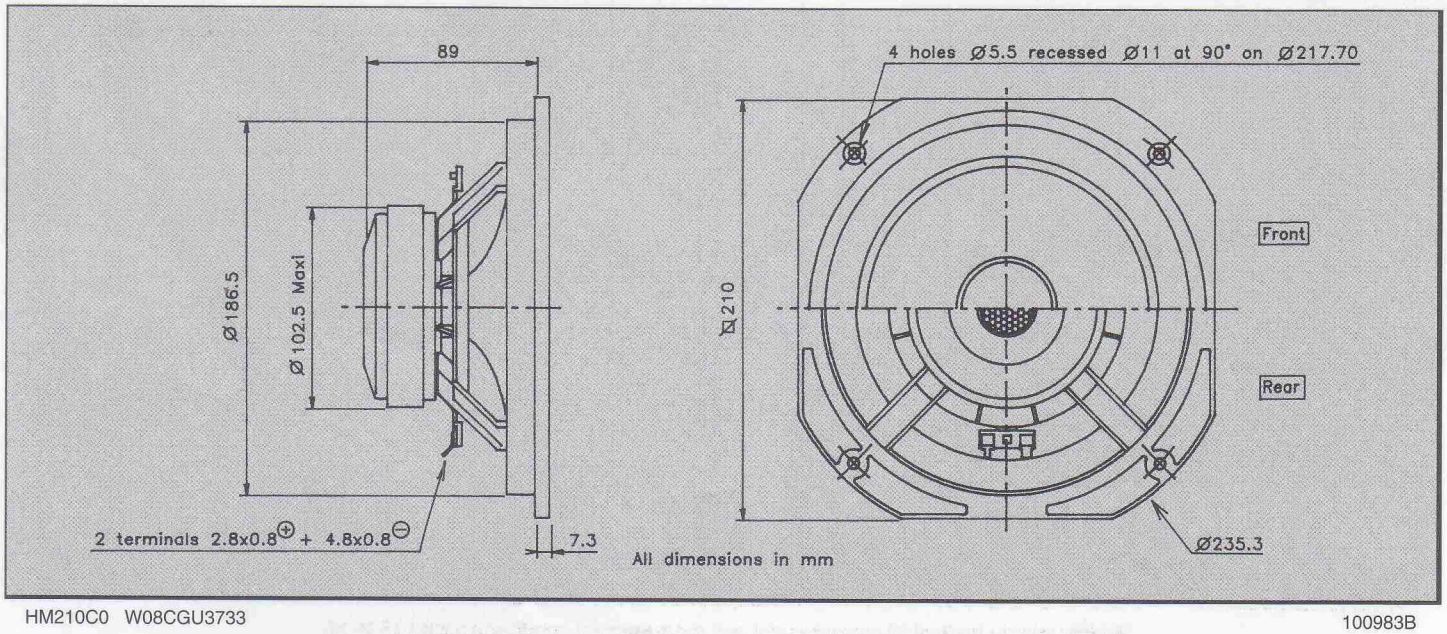
Non resonant die cast chassis
Ventilated chassis under spider
Woven carbon fiber cone
High Loss, high compliance rubber suspension
Edgewound, flat copper wire
Kapton voice coil former
Vented pole piece with protection grill
Gold plated terminals

Châssis Zamak moulé non résonant
Fond ventilé
Cône en fibres de carbone tressées
Suspension caoutchouc haute compliance
Fil cuivre plat sur chant
Bobine sur support Kapton
Noyau ventilé - Grille de protection
Connectique plaquée or



Designed for high end 2 or 3-way self standing systems, this 8" Bass-Midrange driver offers the advantages of a very stiff and light woven Carbon Fiber cone coupled to a high loss rubber suspension. Bass reproduction is firm, tight and dynamic while the cone motion is well damped and controlled by the high compliance, high loss rubber surround. Special consideration has been taken to ensure the best possible transient response, and an exceptionally natural top end roll-off. Unobstructed venting of the Zamak die cast chassis, coupled with a grill protected, vented pole piece and a soft polymer dustcap all contribute to the dramatic transient response. High power handling results from the flat, edgewound copper coil mounted onto a fiberglass reinforced Kapton voice coil former. Gold plated terminals offer excellent solderability. The "suggested applications" charts indicate various driver loads, including the box alignment used to measure the response curve (Vb REF). The response curves shown on the diagram indicate the predicted low end response of the driver in the suggested box volume (Vb) with suggested port (Dp-Lp).

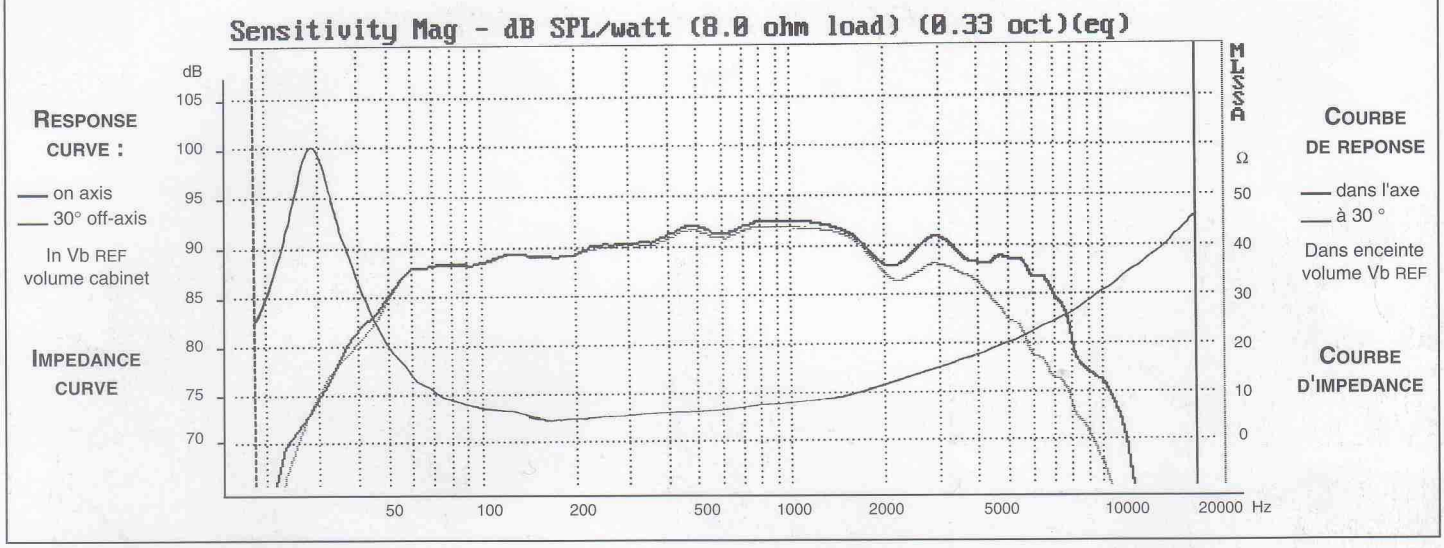
Ce Boomer-Médium de 210 mm, destiné à des sytèmes colonne haut de gamme 2 et 3 voies, est doté d'un cône ultra rigide et très léger en fibres de carbone tressées associé à une suspension en caoutchouc amortissant. Les graves sont fermes, définis, dynamiques. Les ondes stationnaires sont absorbées par la suspension en caoutchouc amortissant. Un soin particulier a été apporté au châssis Zamak moulé ainsi qu'à la structure magnétique afin d'assurer la meilleure réponse en transitoire, ainsi qu'une coupure haute naturelle : châssis ouvert et ventilé sous le spider, noyau ventilé et cache noyau en polymère souple ultra léger. Sa bonne tenue en puissance résulte de l'utilisation d'une bobine sur support Kapton renforcé fibre de verre en fil de cuivre plat sur chant. La connectique plaquée or permet une excellente soudabilité. Le tableau "Suggested applications" indique différents types de charge dont celui utilisé pour la mesure de la courbe de réponse (Vb). Les courbes publiées correspondent à la réponse dans le grave pour un volume (Vb) et une dimension d'évent donnée (Dp-Lp).



HM210C0

BASS MIDRANGE

RESPONSE CURVE
refer to page 16

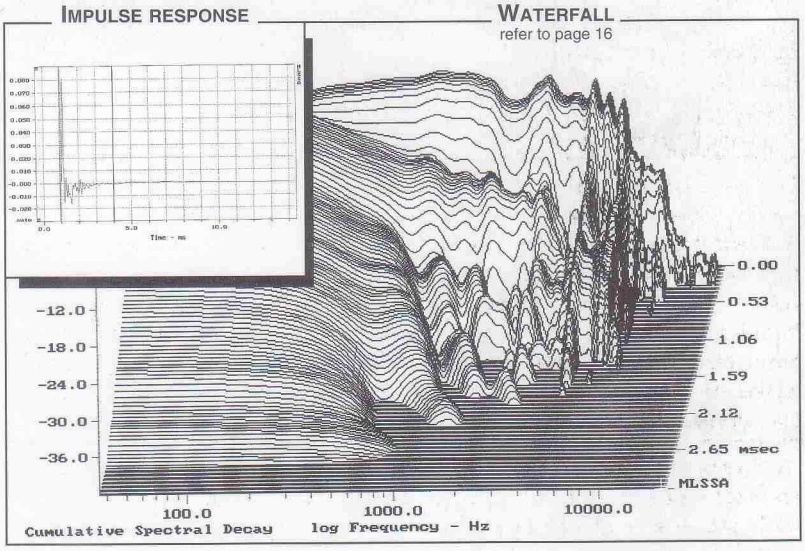


SPECIFICATIONS

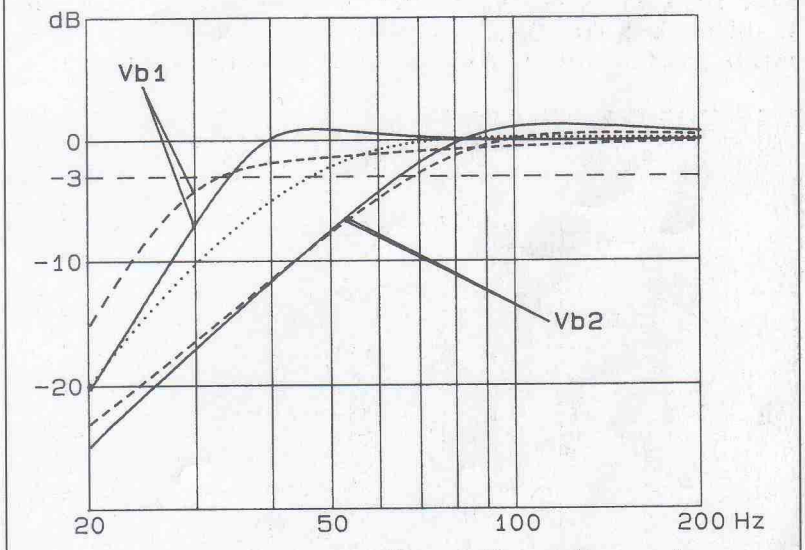
Technical Characteristics	Symbol	Value	Units
PRIMARY APPLICATION			
Nominal Impedance	Z	8	Ω
Resonance Frequency	Fs	31	Hz
Nominal Power Handling	P	70	W
Sensitivity	E	90	dB
VOICE COIL			
Voice coil diameter	Ø	40	mm
Minimum Impedance	Zmin	6,9	Ω
DC Resistance	Re	6,5	Ω
Voice Coil Inductance	Lbm	0,42	mH
Voice coil Length	h	14,3	mm
Former	-	Kapton	-
Number of layers	n	1	-
MAGNET			
Magnet dimensions	Ø x h	100x18	mm
Magnet weight	m	0,55	kg
Flux density	B	1	T
Force factor	BL	8,5	NA^{-1}
Height of magnetic gap	He	6	mm
Stray flux	Fmag	-	Am^{-1}
Linear excursion	Xmax	±4,15	mm
PARAMETERS			
Suspension Compliance	Cms	$1,1.10^{-3}$	mN^{-1}
Mechanical Q Factor	Qms	5,17	-
Electrical Q Factor	Qes	0,42	-
Total Q Factor	Qts	0,39	-
Mechanical Resistance	Rms	0,90	kg s^{-1}
Moving Mass	Mms	$23,5.10^{-3}$	kg
Effective Piston Area	S	$2,32.10^{-2}$	m^2
Volume Equivalent of Air at Cas	Vas	83.10^{-3}	m^3
Mass of speaker	M	2,1	kg

IMPULSE RESPONSE

WATERFALL
refer to page 16



SUGGESTED APPLICATIONS
refer to page 8 to 13



	Vb	Fb	Dp	Lp
Vb 1	75	37	7,5	4,9
	75	30	7,5	9,6
Vb REF	35	35	5	6,9
Vb 2	15	40	5	14,5
	15	30	3,2	10,8

APPLICATION PARAMETERS

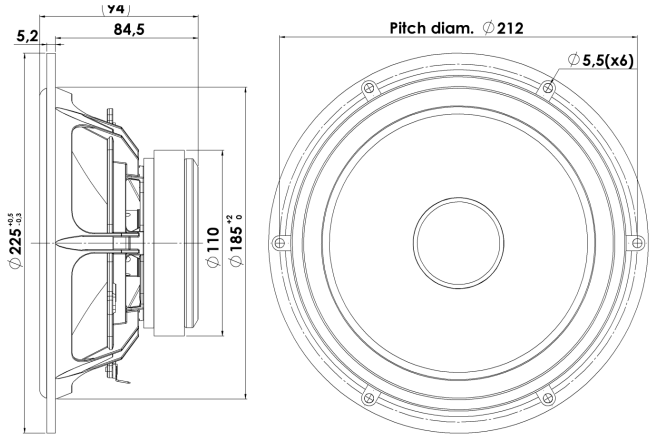
Vb	Box volume	dm^3
Fb	Tuning frequency	Hz
Dp	Port diameter	cm
Lp	Port length	cm

Please refer to method of measurement and measurement conditions pages 15 to 19.

DISCOVERY

WOOFER 22W/8534G00

The Discovery series offer traditional design, superior sound, a solid construction, and a wide range of variants. Combining these elements - plus a wealth of technical features and finesses - it gives our customers the possibility of acquiring a tailor-made Scan-Speak solution with very good performance at a reasonable low price point!



KEY FEATURES:

- High Output 89dB @ 2,83V
- Coated NRSC Fibre Glass Cone
- Low Damping SBR Rubber Surround
- Low Resonance Freq. 30Hz
- Magnet System w. Alu Ring
- Die cast Alu Chassis vented below spider

T-S Parameters	
Resonance frequency [fs]	30 Hz
Mechanical Q factor [Qms]	4.14
Electrical Q factor [Qes]	0.43
Total Q factor [Qts]	0.39
Force factor [Bl]	7.8 Tm
Mechanical resistance [Rms]	1.05 kg/s
Moving mass [Mms]	23.1 g
Suspension compliance [Cms]	1.22 mm/N
Effective diaph. diameter [D]	173 mm
Effective piston area [Sd]	235 cm²
Equivalent volume [Vas]	94.2 l
Sensitivity (2.83V/1m)	88.8 dB
Ratio Bl/√Re	3.21 N/√W
Ratio fs/Qts	77 Hz

Notes:
IEC specs. refer to IEC 60268-5 third edition.
All Scan-Speak products are RoHS compliant.
Data are subject to change without notice.
Datasheet updated: February 22, 2011.

Electrical Data	
Nominal impedance [Zn]	8 Ω
Minimum impedance [Zmin]	6.8 Ω
Maximum impedance [Zo]	62.7 Ω
DC resistance [Re]	5.9 Ω
Voice coil inductance [Le]	0.56 mH

Power Handling	
100h RMS noise test (IEC 17.1)	70 W
Long-term max power (IEC 17.3)	120 W

Voice Coil and Magnet Data	
Voice coil diameter	38 mm
Voice coil height	17.5 mm
Voice coil layers	2
Height of gap	6 mm
Linear excursion	± 5.8 mm
Max mech. excursion	± 12 mm
Unit weight	2.1 kg

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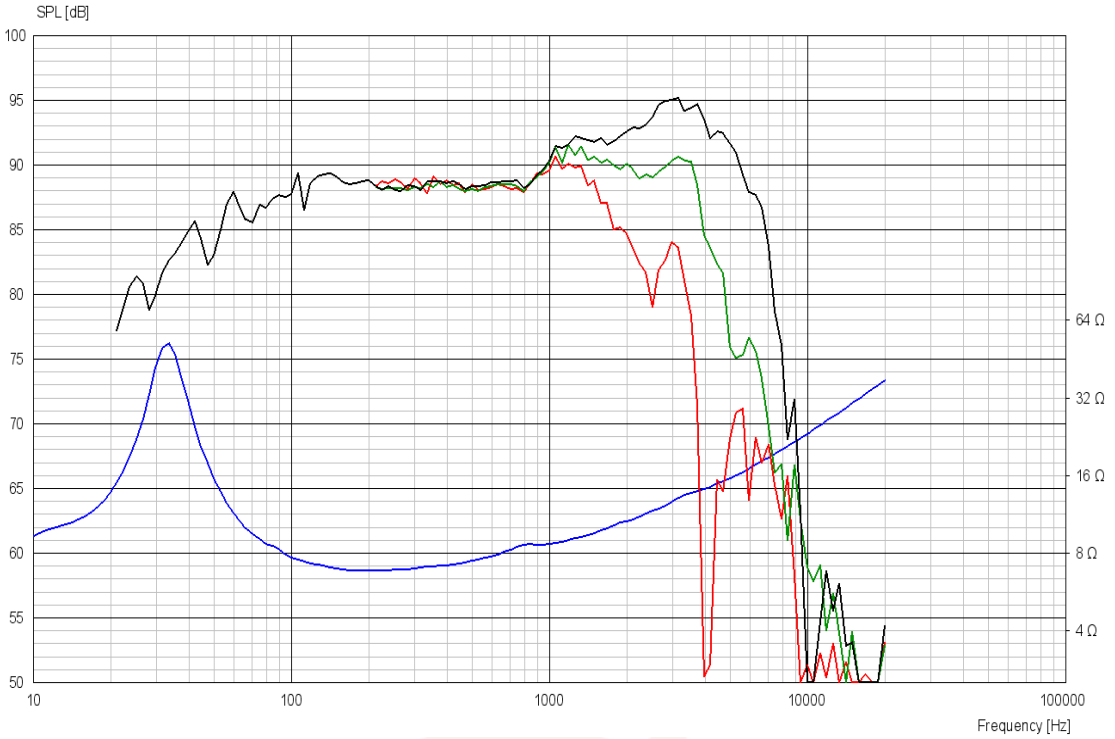
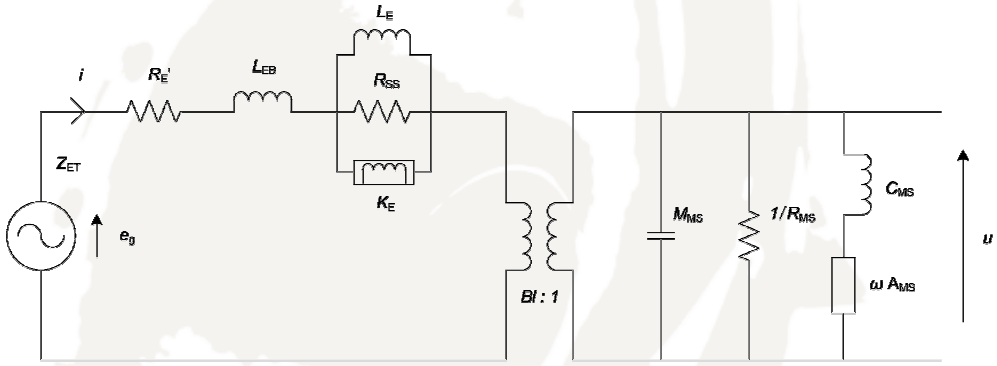


Advanced Parameters (Preliminary)



Electrical data:	
Resistance [Re']	- Ω
Free inductance [Leb]	- mH
Bound inductance [Le]	- mH
Semi-inductance [Ke]	- SH
Shunt resistance [Rss]	- Ω

Mechanical Data	
Force Factor [Bl]	- Tm
Moving mass [Mms]	- g
Compliance [Cms]	- mm/N
Mechanical resistance [Rms]	- kg/s
Admittance [Ams]	- mm/N

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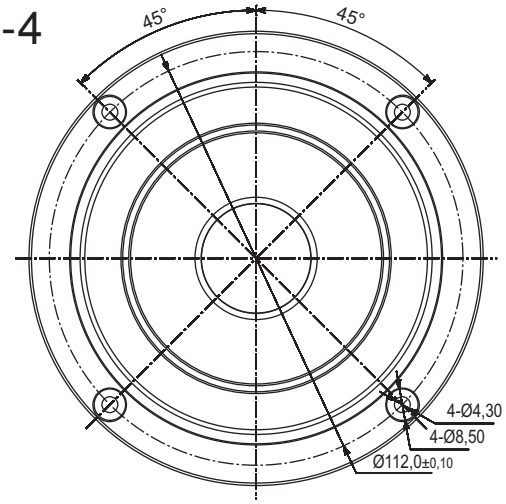
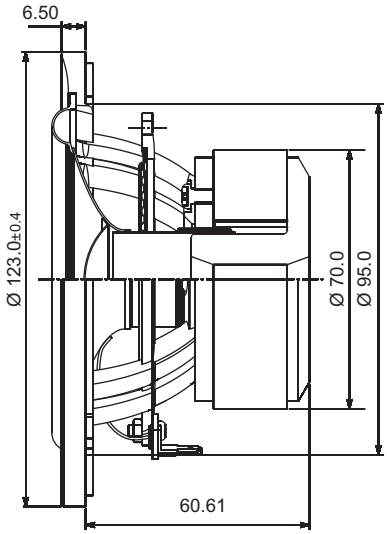
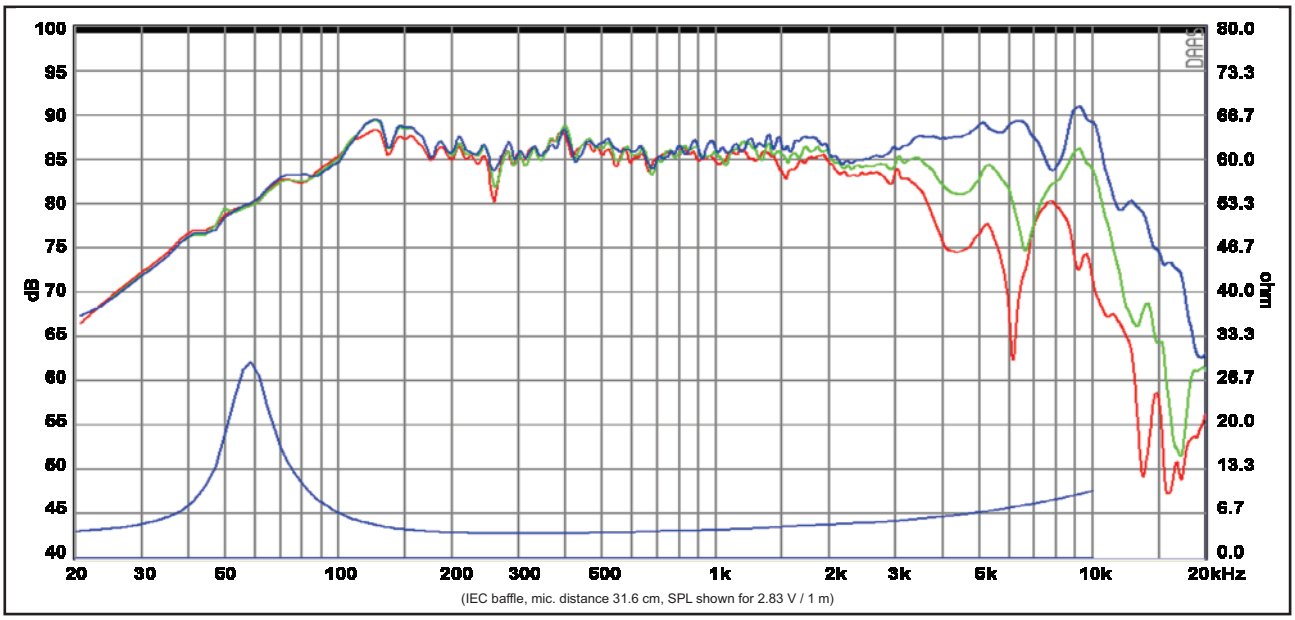
SB ACOUSTICS

4” SB12NRXF25-4







Response Curve :

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

Specs :

Nominal Impedance	4 Ω	Free air resonance, Fs	61 Hz
DC resistance, Re	3.1 Ω	Sensitivity (2.83 V / 1 m)	87 dB
Voice coil inductance, Le	0.27 mH	Mechanical Q-factor, Qms	5.3
Effective piston area, Sd	50 cm^2	Electrical Q-factor, Qes	0.53
Voice coil diameter	25.4 mm	Total Q-factor, Qts	0.48
Voice coil height	15 mm	Moving mass incl.air, Mms	5.8 g
Air gap height	5 mm	Force factor, Bl	3.6 Tm
Linear coil travel (p-p)	10 mm	Equivalent volume, Vas	4.1 liters
Magnetic flux density	0.84 T	Compliance, Cms	1.17 mm/N
Magnet weight	0.32 kg	Mechanical loss, Rms	0.42 kg/s
Net weight	0.75 kg	Rated power handling*	30 W

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

MU10RB-SL
H1658-04

The MU10RB is an 4” full range driver offering an extraordinary performance and sound clarity.

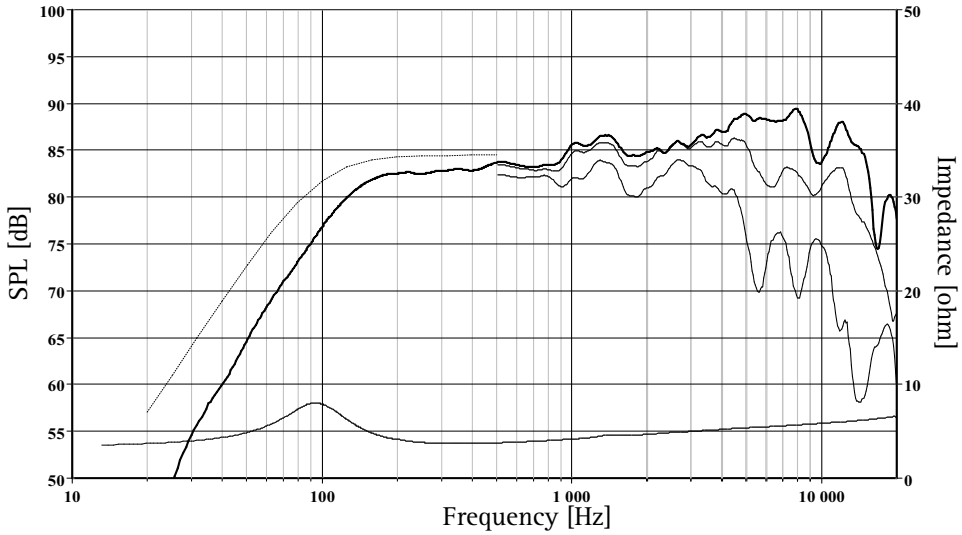
New Curv cone, a woven polypropylene with excellent internal damping together with perfectly matched moving parts gives a smooth, extended frequency response.

A high loss natural rubber surround makes this driver perform its best as a mid-range.

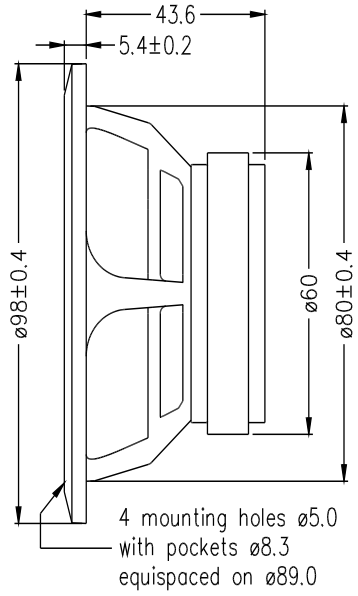
The large, open weave fabric spider reflects very little acoustic energy to the cone, and offers excellent stiffness linearity.

A stiff and stable injection moulded aluminum chassis keeps the critical components in perfect alignment. The pole piece is prolonged forwards and equipped with a deep drawn copper cap to ensure excellent linearity in the force factor and coil inductance.

Small size combined with an excellent performance makes this driver the perfect election for any application where limited space is a critical parameter.



The frequency responses above show measured free field sound pressure in 0, 30, and 60 degrees angle using a 2.5L closed box. Input 2.83 Vrms, microphone distance 0.5m, normalized to SPL 1m.The dotted line is a calculated response in infinite baffle based on the parameters given for this specific driver. The impedance is measured in free air without baffle using a 2V sine signal.



Nominal Impedance	4 Ohms	Voice Coil Resistance	3.3 Ohms
Recommended Frequency Range	100 - 20000 Hz	Voice Coil Inductance	0.14 mH
Short Term Power Handling *	100 W	Force Factor	2.9 N/A
Long Term Power Handling *	40 W	Free Air Resonance	100 Hz
Characteristic Sensitivity (2,83V, 1m)	84.7 dB	Moving Mass	4.51 g
Voice Coil Diameter	19 mm	Air Load Mass In IEC Baffle	0.14 g
Voice Coil Height	8 mm	Suspension Compliance	0.6 mm/N
Air Gap Height	4 mm	Suspension Mechanical Resistance	1.8 Ns/m
Linear Coil Travel (p-p)	4 mm	Effective Piston Area	38.5 cm^2
Maximum Coil Travel (p-p)	7.9 mm	VAS	1.1 Litres
Magnetic Gap Flux Density	0.9 T	QMS	1.63
Magnet Weight	0.09 kg	QES	1.15
Total Weight	0.36 kg	QTS	0.67

Oct 2011

*IEC 268-5

SEAS reserves the right to change technical data

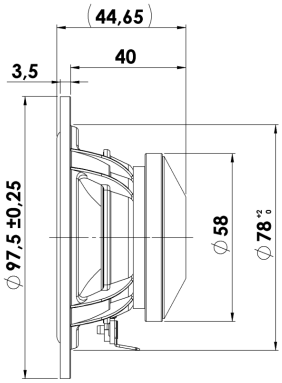
RoHS compliant product

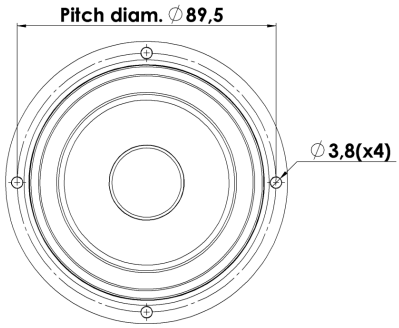
www.seas.no

DISCOVERY

FULLRANGE 10F/8424G00

The Discovery series offer traditional design, superior sound, a solid construction, and a wide range of variants. Combining these elements - plus a wealth of technical features and finesses - gives our customers the possibility of acquiring a tailor-made Scan-Speak solution with very good performance at a reasonable low price point!





KEY FEATURES:

- Very wide Frequency Range
- Coated NRSC Fibre Glass Cone (patent)
- Compact Size, Neo magnet, Alu. Chassis
- High Sensitivity 87dB / 2,83V
- SBR Rubber Surround
- Copper Cap on Pole Piece

T-S Parameters	
Resonance frequency [fs]	90 Hz
Mechanical Q factor [Qms]	3.49
Electrical Q factor [Qes]	0.41
Total Q factor [Qts]	0.37
Force factor [Bl]	4.8 Tm
Mechanical resistance [Rms]	0.45 kg/s
Moving mass [Mms]	2.77 g
Suspension compliance [Cms]	1.13 mm/N
Effective diaph. diameter [D]	68 mm
Effective piston area [Sd]	36 cm²
Equivalent volume [Vas]	2.1 l
Sensitivity (2.83V/1m)	86.6 dB
Ratio Bl/√Re	1.99 N/√W
Ratio fs/Qts	245 Hz

Notes:
IEC specs. refer to IEC 60268-5 third edition.
All Scan-Speak products are RoHS compliant.
Data are subject to change without notice.
Datasheet updated: February 22, 2011.

Electrical Data	
Nominal impedance [Zn]	8 Ω
Minimum impedance [Zmin]	6.5 Ω
Maximum impedance [Zo]	55.2 Ω
DC resistance [Re]	5.8 Ω
Voice coil inductance [Le]	0.13 mH

Power Handling	
100h RMS noise test (IEC 17.1)	15 W
Long-term max power (IEC 17.3)	30 W

Voice Coil and Magnet Data	
Voice coil diameter	20 mm
Voice coil height	9.2 mm
Voice coil layers	2
Height of gap	4 mm
Linear excursion	± 2.6 mm
Max mech. excursion	± 7 mm
Unit weight	0.3 kg

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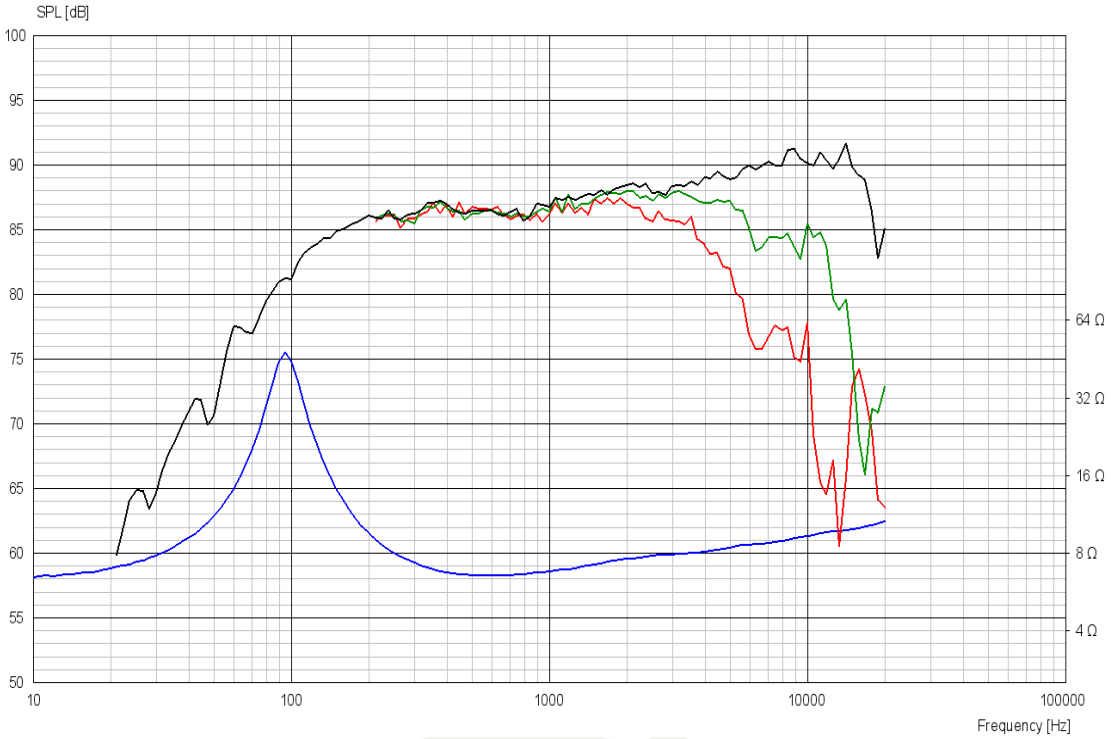
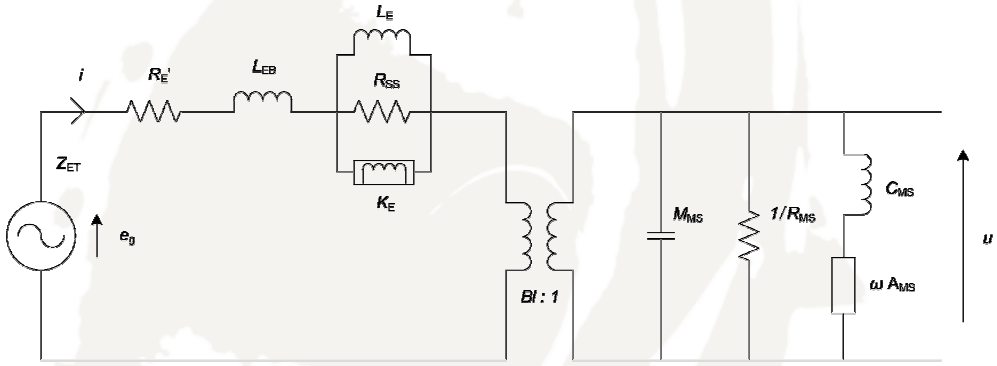
DISCOVERY

FULLRANGE 10F/8424G00



Advanced Parameters (Preliminary)



Electrical data:	
Resistance [Re']	5.70 Ω
Free inductance [Leb]	0.0323 mH
Bound inductance [Le]	0.346 mH
Semi-inductance [Ke]	0.0342 SH
Shunt resistance [Rss]	4.72 Ω

Mechanical Data	
Force Factor [Bl]	4.43 Tm
Moving mass [Mms]	2.93 g
Compliance [Cms]	1.02 mm/N
Mechanical resistance [Rms]	0.260 kg/s
Admittance [Ams]	0.167 mm/N

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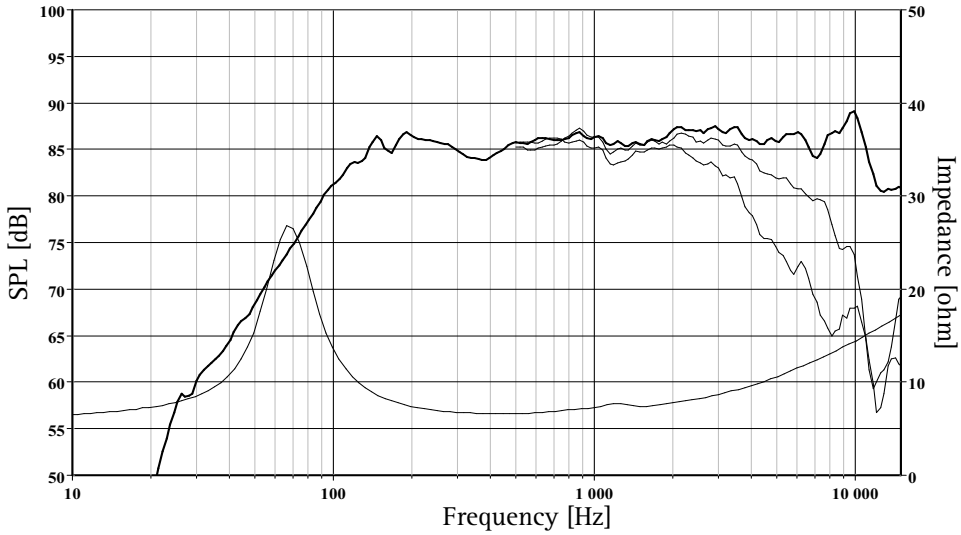
MCA12RC
H1304

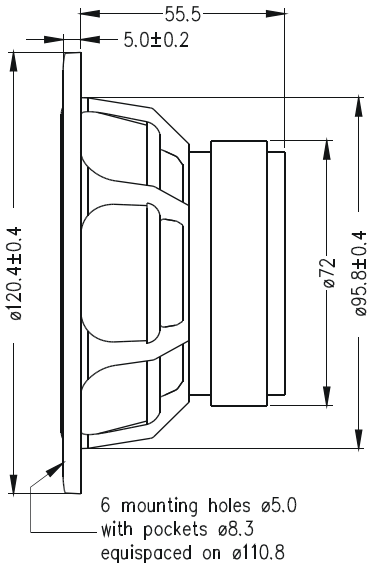
Manually coated paper cone and mechanically matching natural rubber surround result in an unusually smooth midrange response.

1" high temperature voice coil is wound on an aluminium voice coil former to ensure a very high power handling capacity.

Extremely stiff and stable injection moulded metal basket keeps the critical components in perfect alignment. Large windows in the basket both above and below the spider reduce sound reflexion, air flow noise and cavity resonance to a minimum.



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



Nominal Impedance	8 Ohms	Voice Coil Resistance	6.3 Ohms
Recommended Frequency Range	400 - 5000 Hz	Voice Coil Inductance	0.31 mH
Short Term Power Handling *	400 W	Force Factor	4.2 N/A
Long Term Power Handling *	110 W	Free Air Resonance	68 Hz
Characteristic Sensitivity (2.83V, 1m)	86.0 dB	Moving Mass	4.58 g
Voice Coil Diameter	26 mm	Air Load Mass In IEC Baffle	0.24 g
Voice Coil Height	5.8 mm	Suspension Compliance	1.2 mm/N
Air Gap Height	4.0 mm	Suspension Mechanical Resistance	0.85 Ns/m
Linear Coil Travel (p-p)	1.8 mm	Effective Piston Area	55 cm^2
Maximum Coil Travel (p-p)	-	VAS	5 Litres
Magnetic Gap Flux Density	1.1 T	QMS	2.42
Magnet Weight	0.25 kg	QES	0.74
Total Weight	0.66 kg	QTS	0.56

Jul 2007-1 *IEC 268-5 M12-101

SEAS reserves the right to change technical data

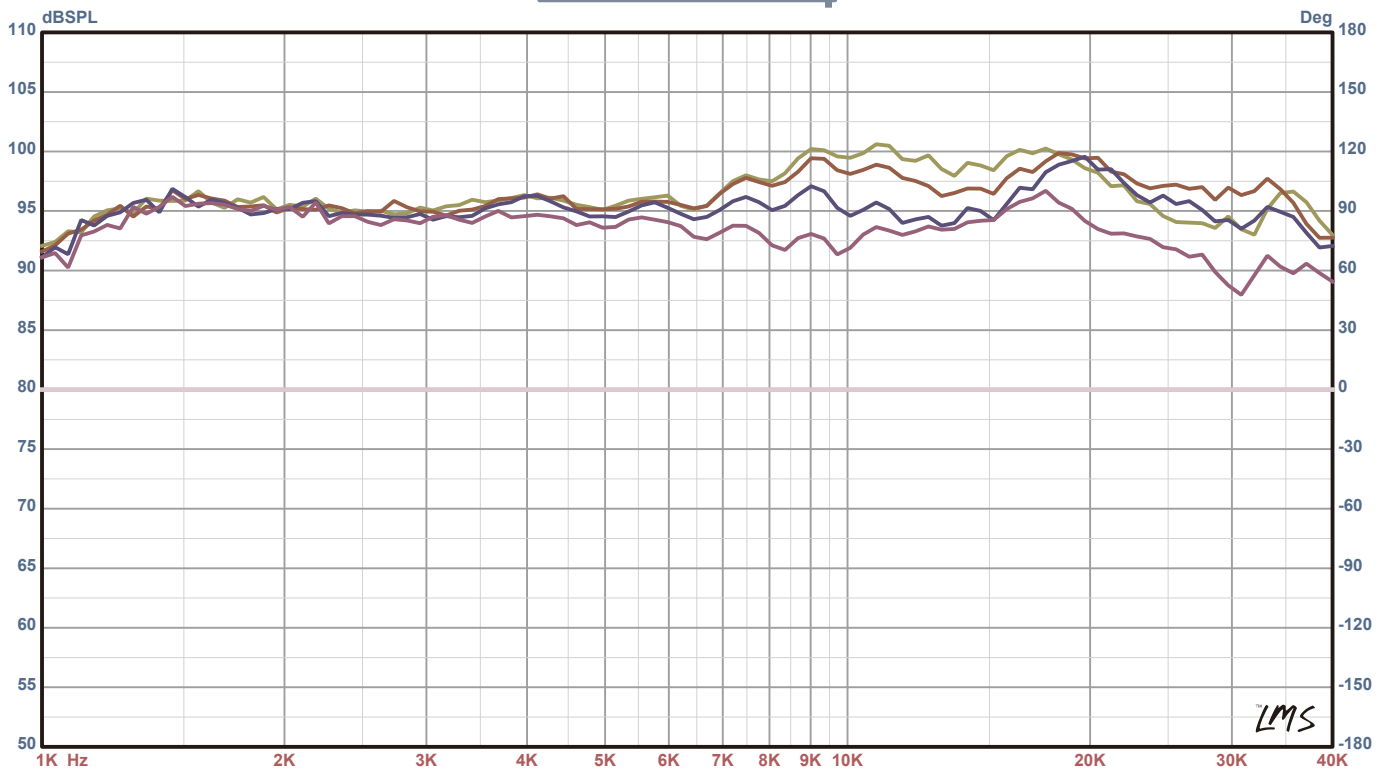
RoHS compliant product www.seas.no

NeoCD2.0 True Ribbon Tweeter

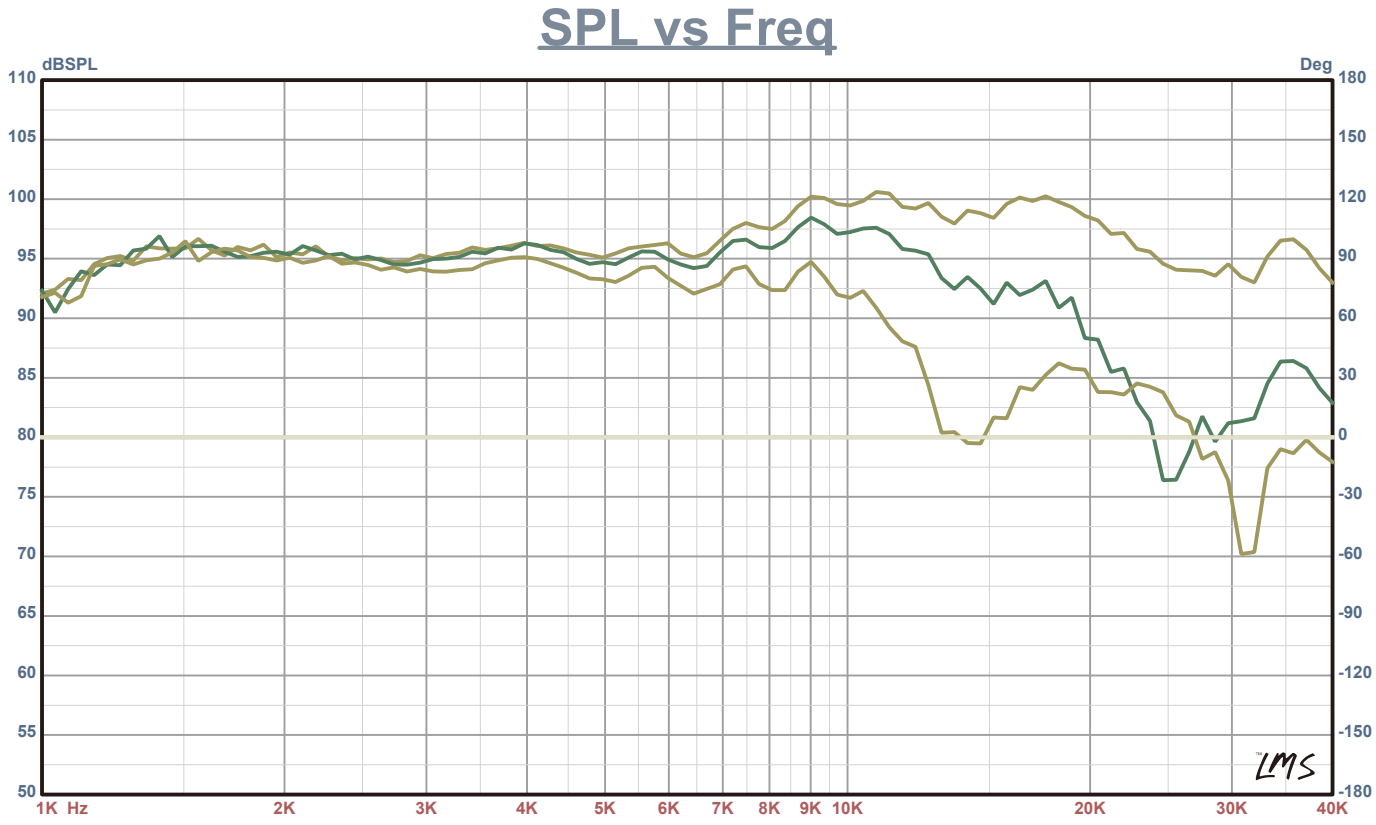
FEATURES
- strong Neodymium magnet
- 5 inch enforced sandwich diaphragm
- build-in impedance convertor
- low distortion, very fast transition

Parameter	
Sensitivity	97dB/1m/2.83v
Power handling	20W nominal, 50W max
Frequency range	1,200-40,000Hz
Nominal impedance	7 ohm
DCR	0.02 ohm
Ribbon dimension	8mmX120mmX0.015mm
Effective ribbon area	960 square millimeter
Ribbon weight	36 milligram
Gap flux	0.6 Telsa average
Gap height	3 millimeter
Recommend crossover frequency	2,500Hz with 3-order
Net. Weight	1050 gram

www.fountek.net
email: info@fountek.net
tel: +86-573-8301 9220 fax: +86-573-8301 9221



horizontal diffusion: on-axis, 15 degree , 30 degree, 45 degree



vertical diffusion: on-axis, 5 degree , 10 degree

www.fountek.net
email: info@fountek.net
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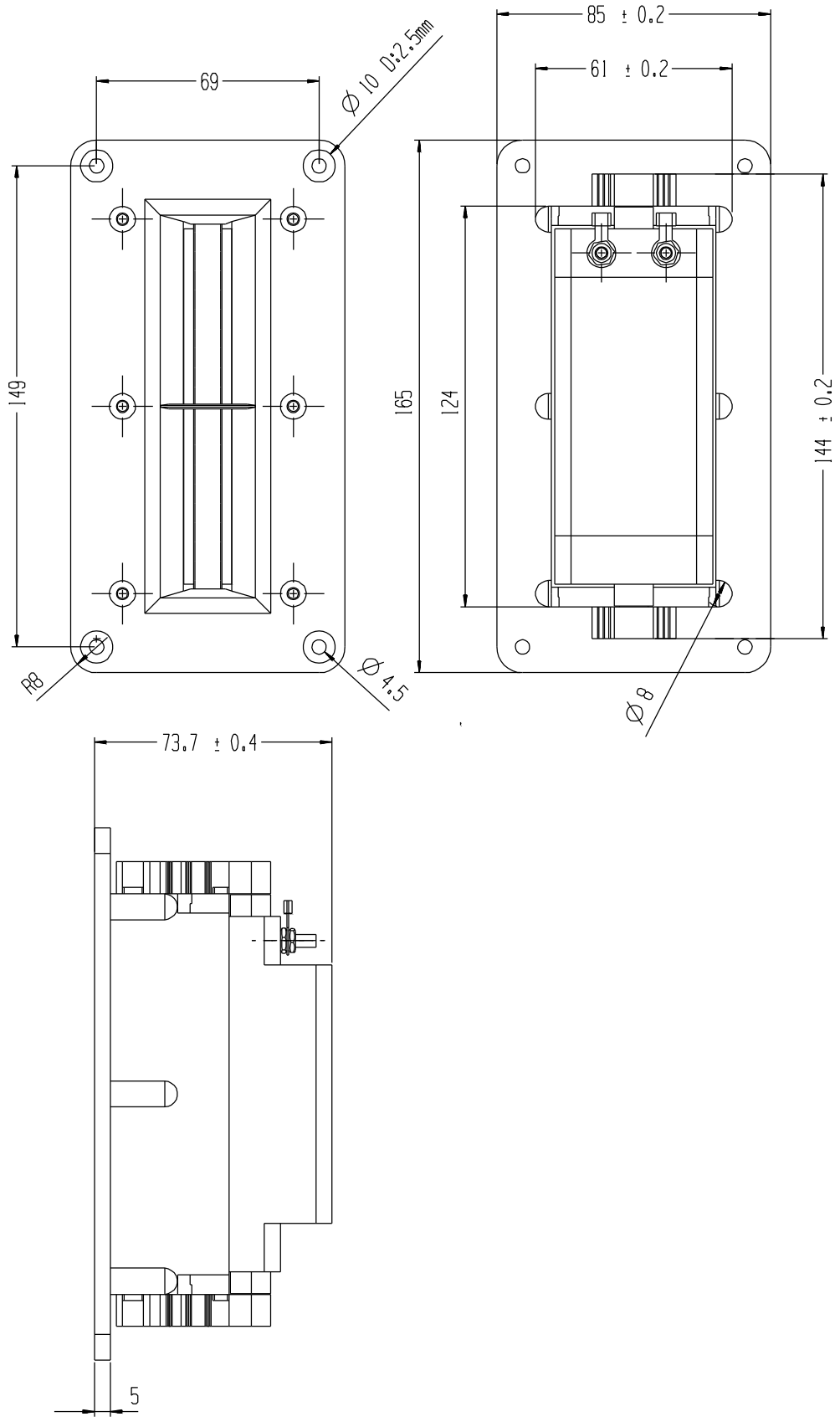

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email: info@fountek.net
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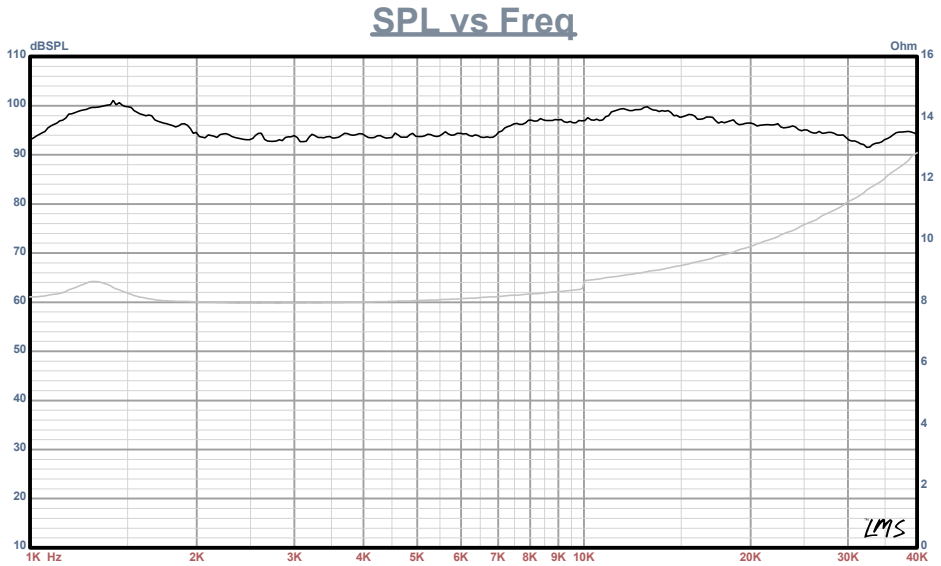
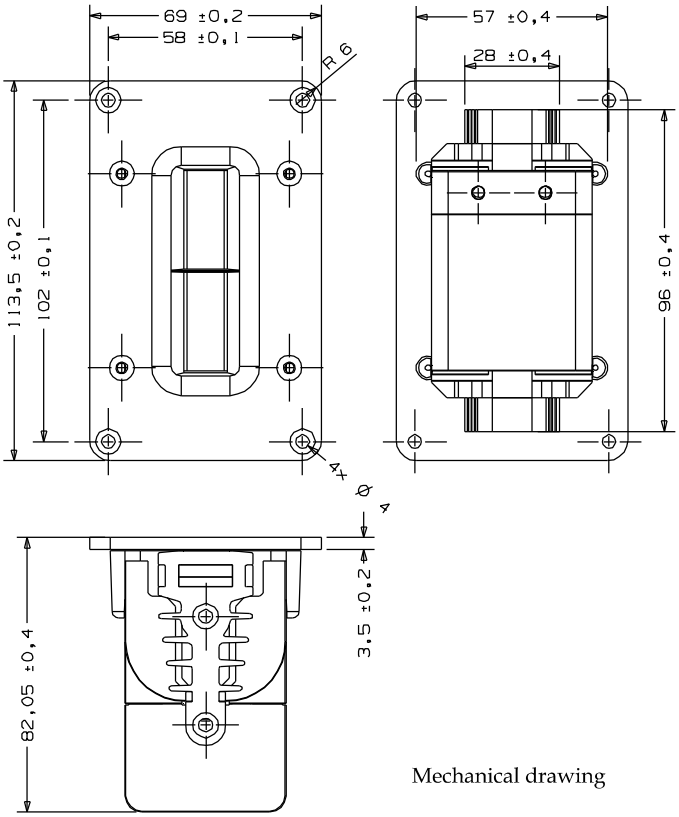
NeoX2.0 ribbon tweeter

Feature
- Fountek's 3-rd generation ribbon driver technology
- 12mm width enforced sandwich ribbon diaphragm
- Higher power handling, lower distortion, very fast transition
- Strong Neodymium magnet
- Built-in impedance convertor



on-axis frequency response

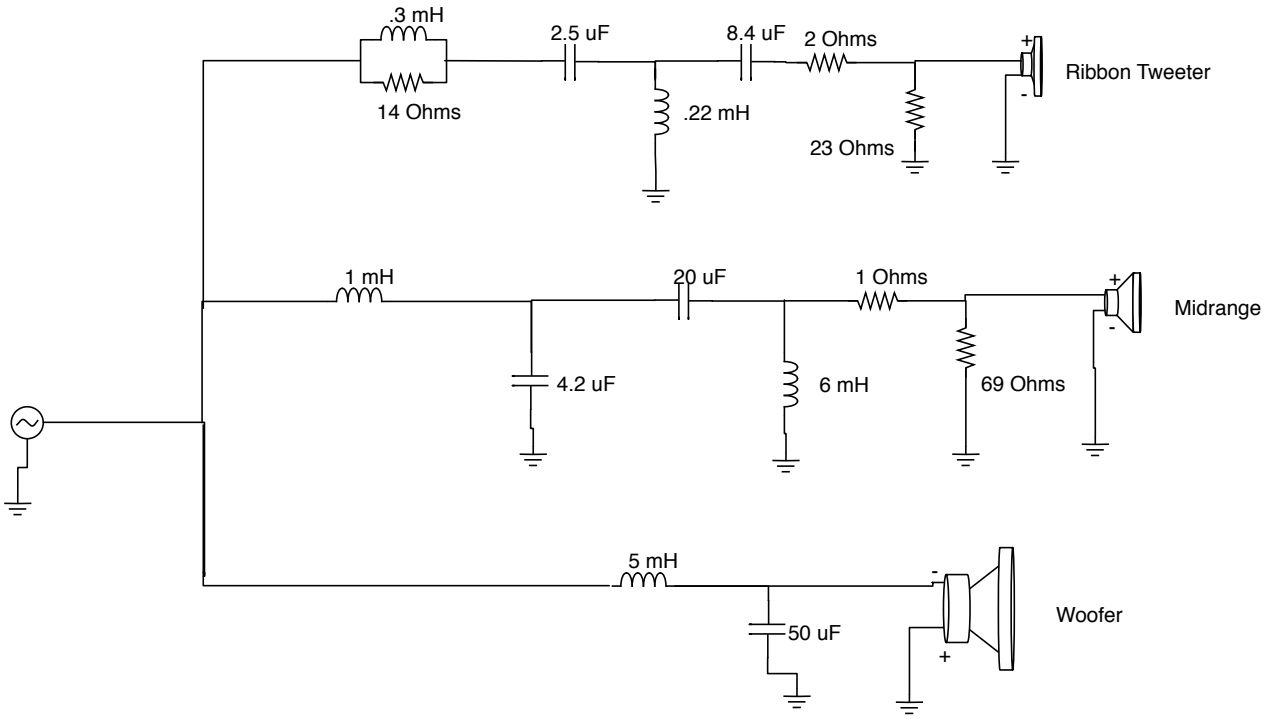
RIBBON TWEETER



Mechanical drawing

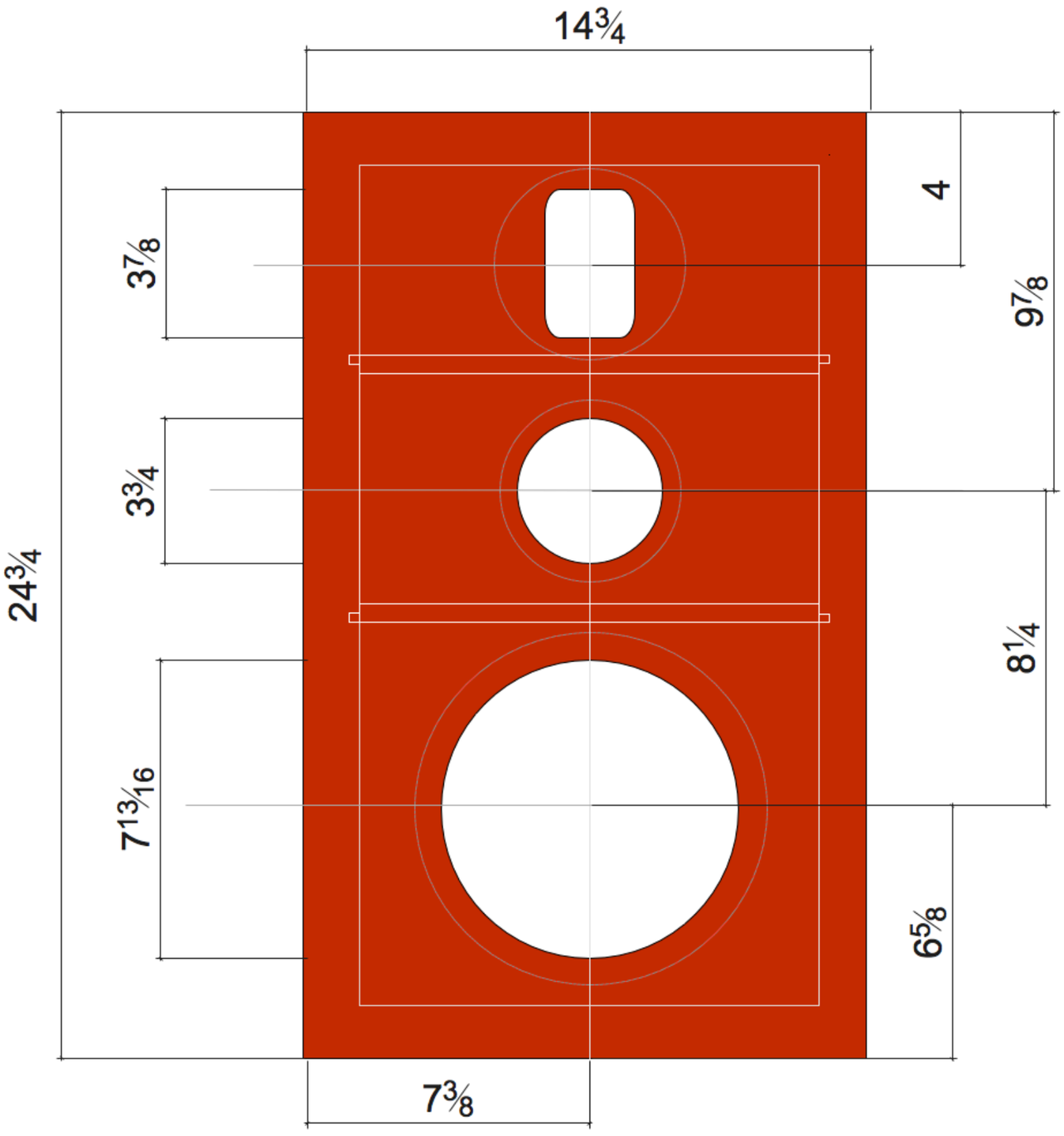
Parameter	
Sensitivity	94dB/1m/2.83v
Power handling	25W nominal, 43W max
Frequency range	1,200-40,000Hz
Nominal impedance	8 ohm
DCR	0.02 ohm
Ribbon dimension	12x60x0.015mm
Effective ribbon area	720 square millimeter
Ribbon weight	27 milligram
Gap flux	0.4 Telsa average
Gap height	13 millimeter
Recommend crossover frequency	2,300Hz with 2-order
Net. Weight	750 gram

Address: No. 112 Lu Li Street, Jia Xing, Zhe Jiang 314001,PRC
Tel: +86 - 573 - 8301 9220 **Fax: +86 - 573 - 8301 9221**
Website: www.fountek.net **e-mail: info@fountek.net**

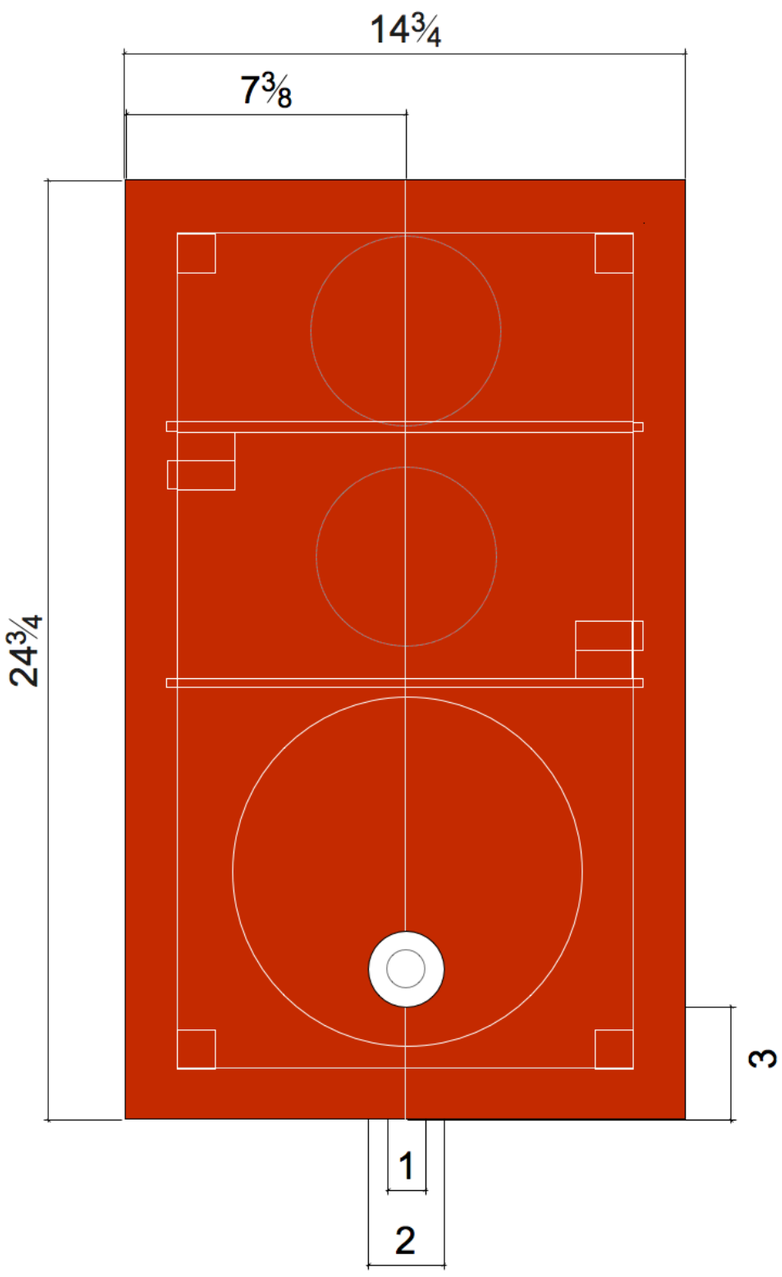


Production/Project: **Renata's Speakers**		
Location: **Michigan Technological University**		
Director: **N/A**	Designers: **Renata Putzig**	
Drafted by: **Renata Putzig**	Date Drawn: **01/29/13**	Revision #: **1**
Production Date: **2013**	Scale: **N/A**	Drawing #: **1 of 1**
Drawing Title: **Crossover Schematic**		

Front View

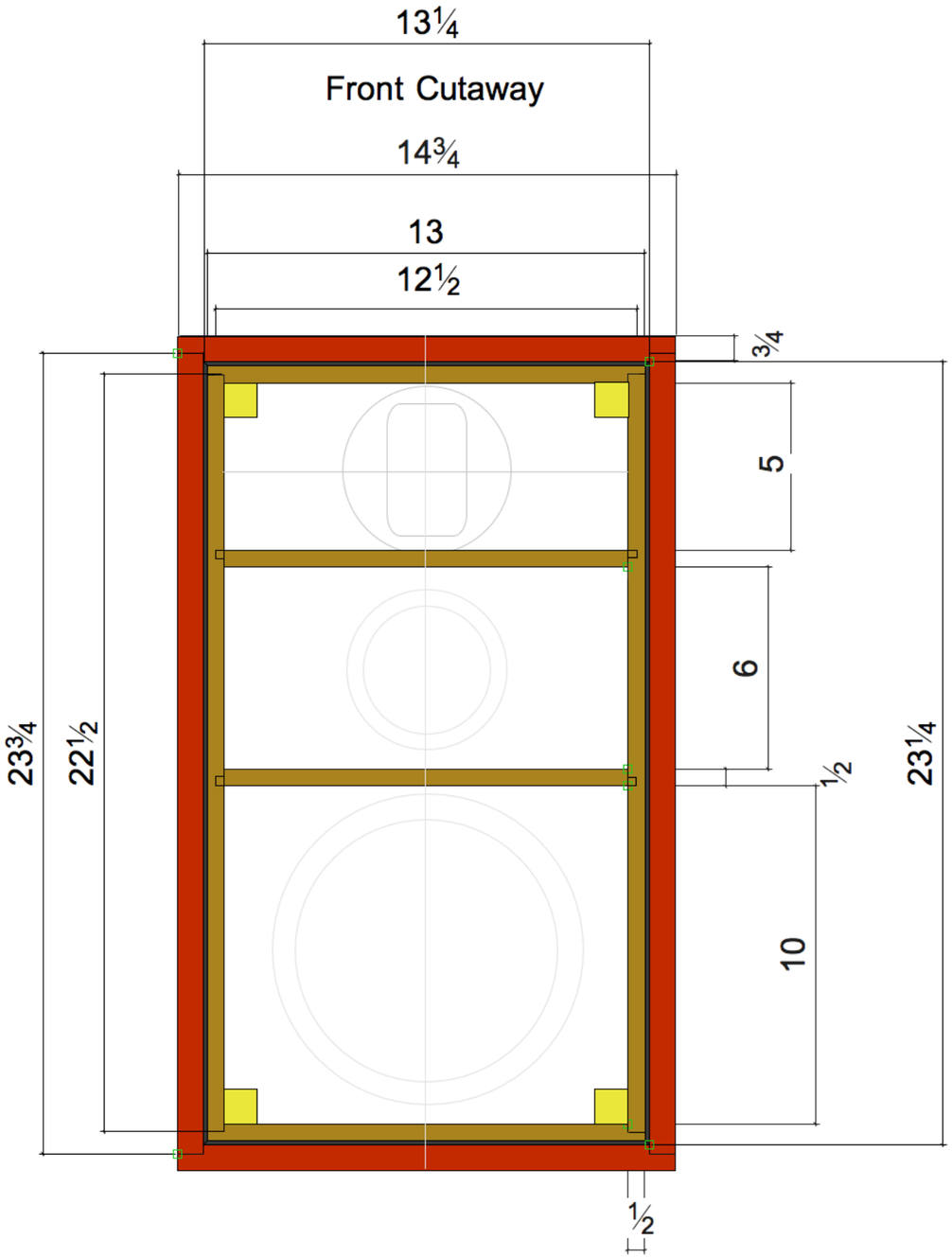


Back View

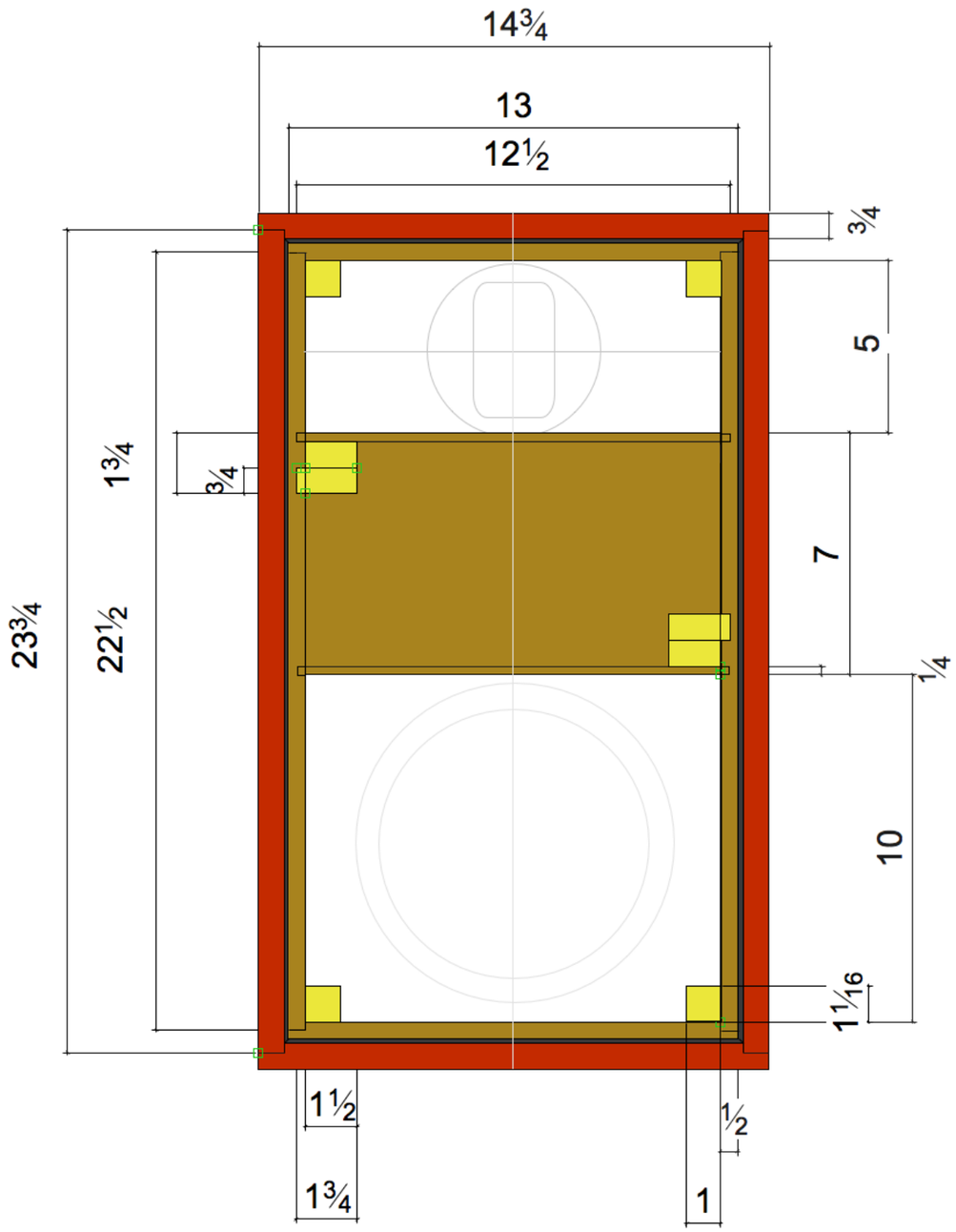


Project: **RP38 Speakers**		
Location: **Michigan Technological University**		
Designer: **Renata Putzig**		
Drafted by: **Renata Putzig**	Date Drawn: **03/27/13**	Revision #: **3**
Year: **2013**	Scale: **NTS**	Drawing #: **1 of 4**
Drawing Title: **Front/Back View**		

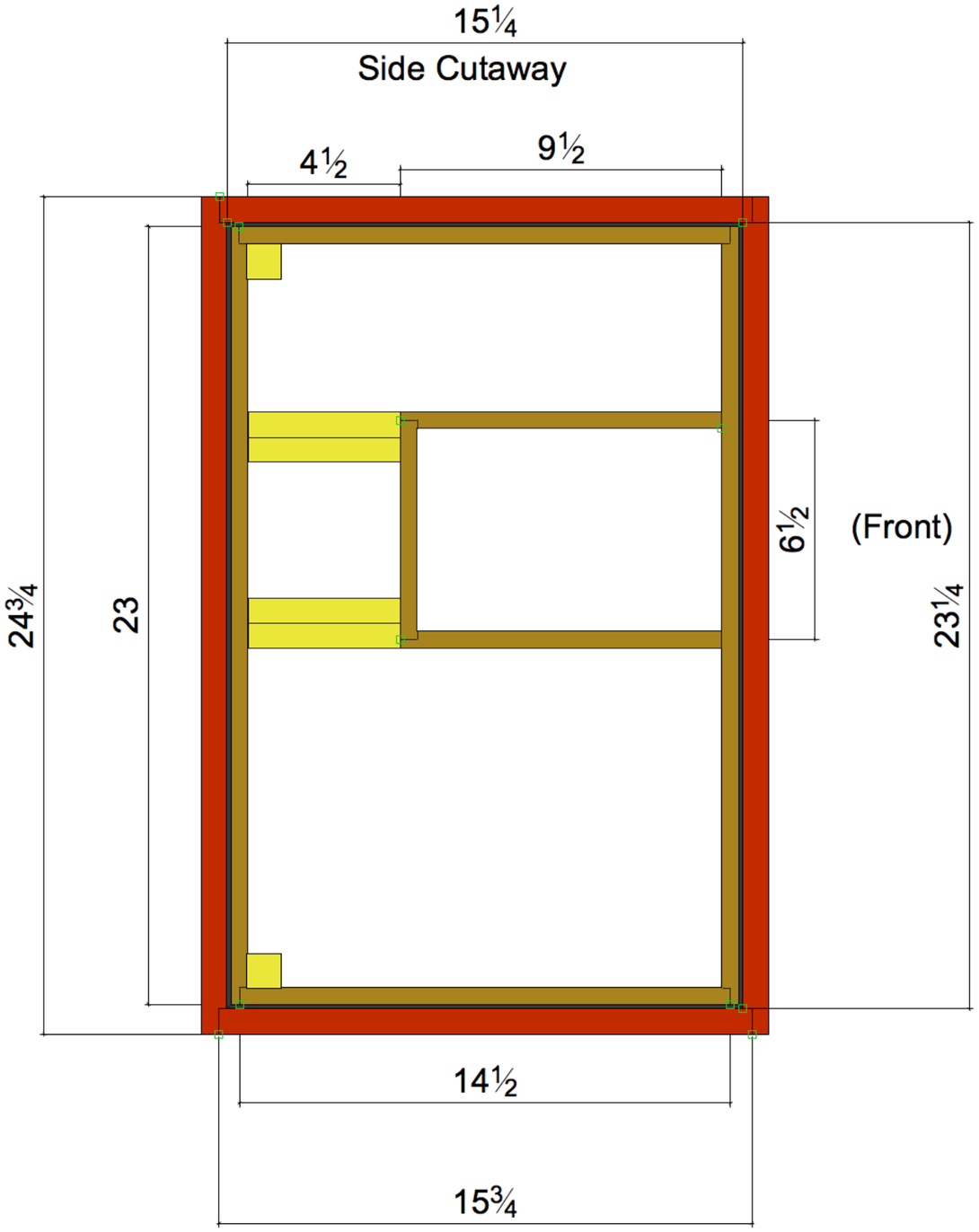
Front Cutaway

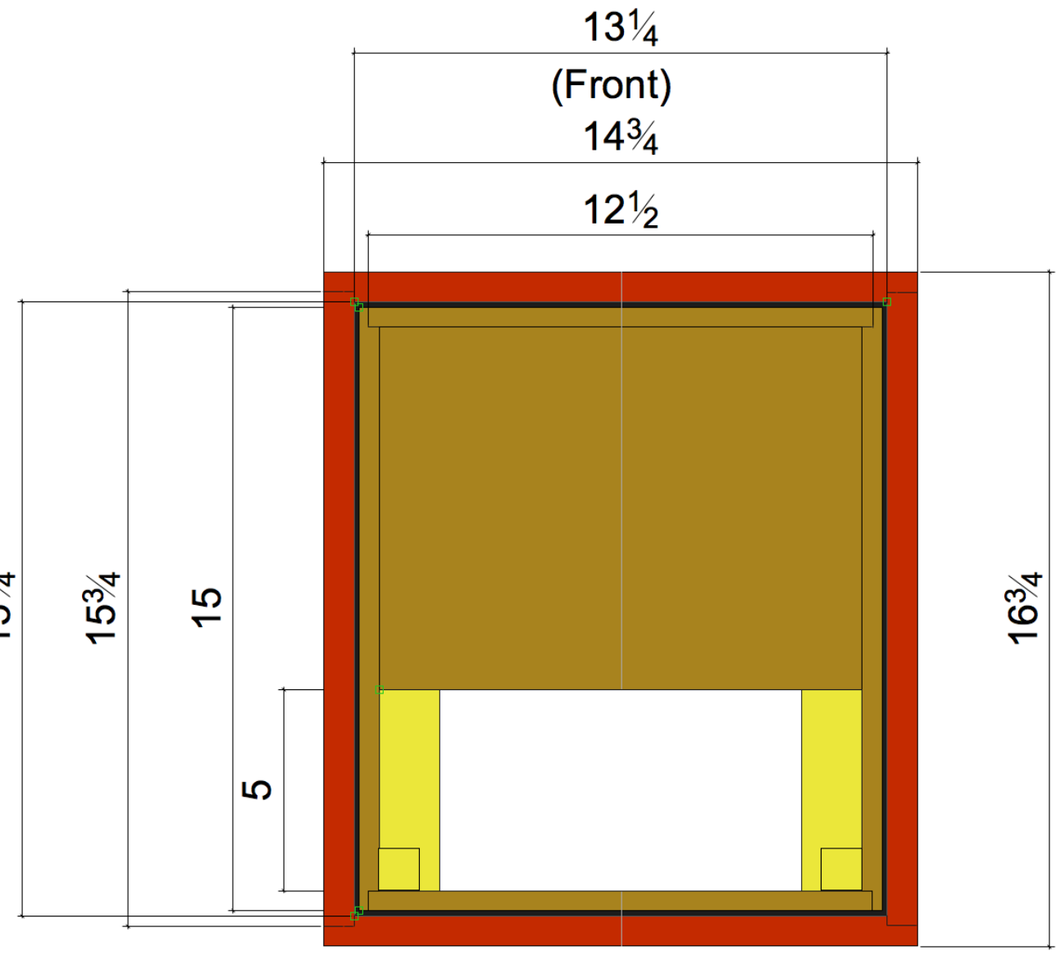


Back Cutaway

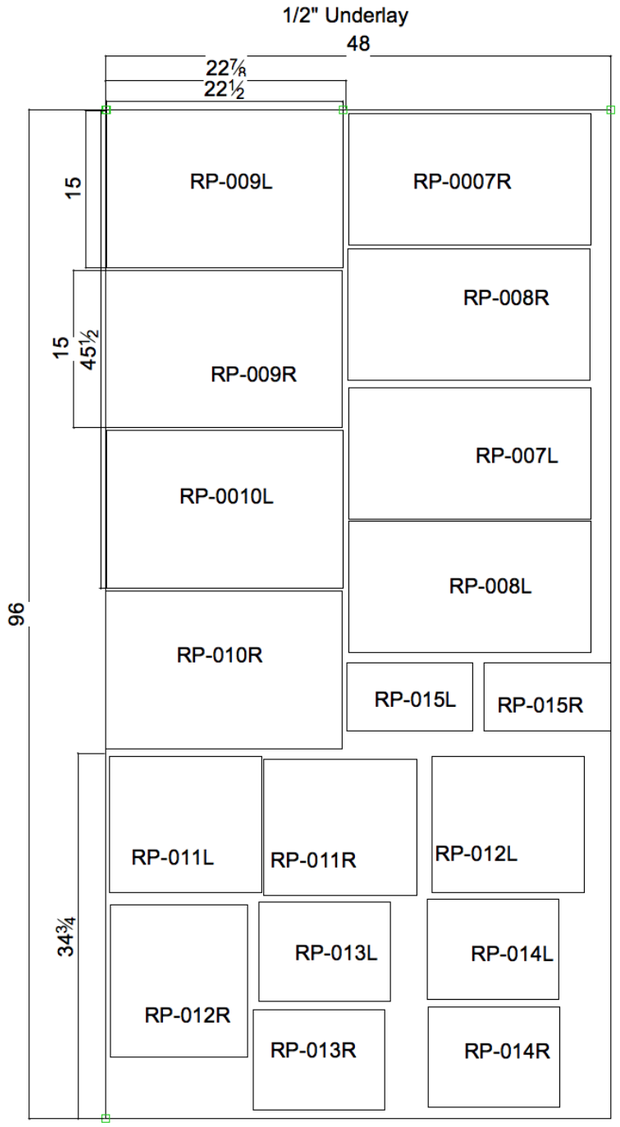


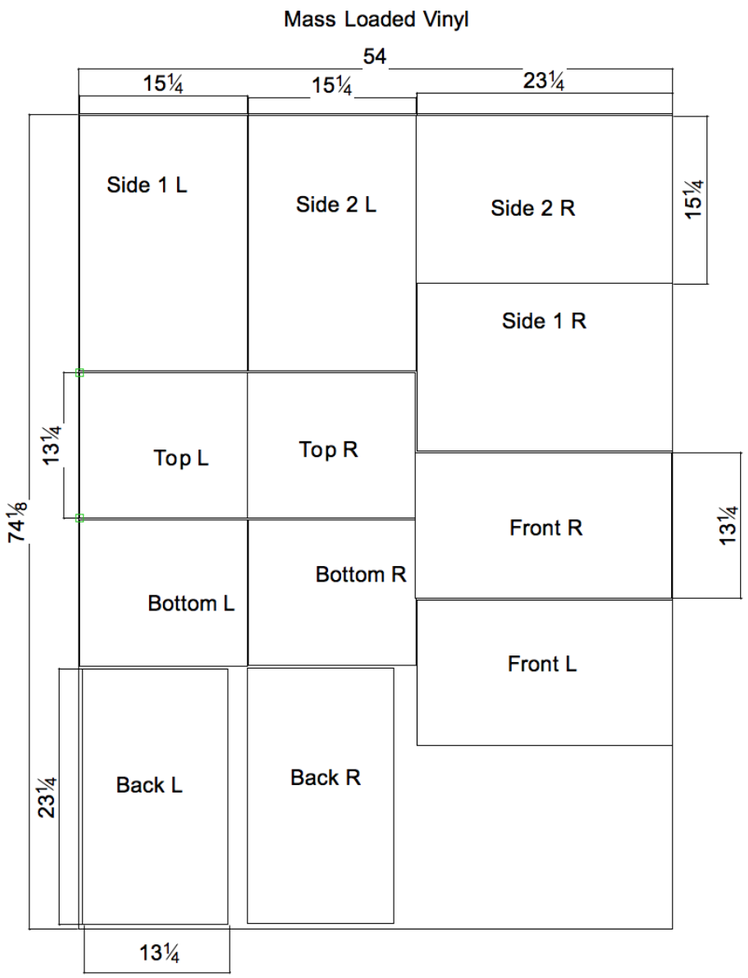
Project: **RP38 Speakers**		
Location: **Michigan Technological University**		
Designer: **Renata Putzig**		
Drafted by: **Renata Putzig**	Date Drawn: **03/27/13**	Revision #: **3**
Year: **2013**	Scale: **NTS**	Drawing #: **2 of 4**
Drawing Title: **Cutaway Front/Back View**		

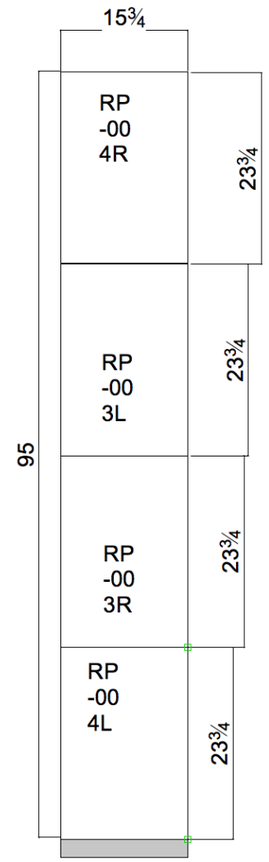


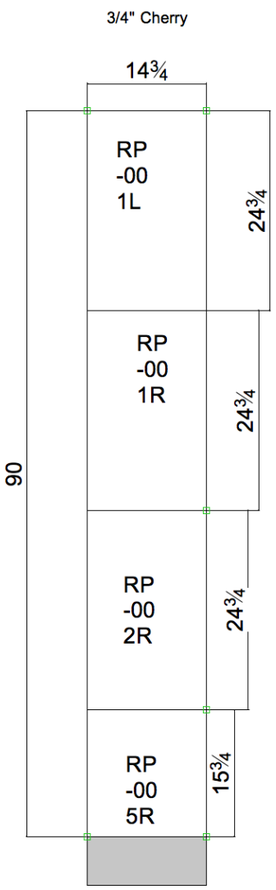


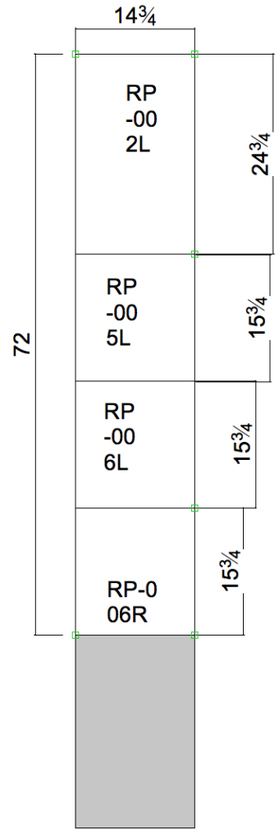
Project: **RP38 Speakers**		
Location: **Michigan Technological University**		
Designer: **Renata Putzig**		
Drafted by: **Renata Putzig**	Date Drawn: **03/27/13**	Revision #: **3**
Year: **2013**	Scale: **NTS**	Drawing #: **3 of 4**
Drawing Title: **Cutaway Top/Side View**		











Project: **RP38 Speakers**		
Location: **Michigan Technological University**		
Designer: **Renata Putzig**		
Drafted by: **Renata Putzig**	Date Drawn: **03/27/13**	Revision #: **3**
Year: **2013**	Scale: **NTS**	Drawing #: **4 of 4**
Drawing Title: **Cutsheets**		

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