

Transducer Theory Loudspeaker Design

FA4740

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Functional Goals

The speakers I intend to build will be used as studio/mixing monitors. They will be the main form of playback for my computer where I do most if not all of my song and sound creation. Since they are mixing monitors, they will need to accurately reproduce the entire spectrum of human hearing as closely as possible and with as little distortion or coloration as possible. Also, since most home listening happens around the 75dB to 85dB range, my speakers will be able to produce sound of high quality in that range as well as louder if needed.¹

Given that I'm not sure where these speakers are going to live I am going to build the cabinets to best reproduce sounds in a functionally sized box. They will not be small bookshelf speakers nor will they be leviathans that stand 6 feet tall like the Wilson Audio Specialties MAXX Series 2. They will be roughly the same size as the CM-7s in 212, which should allow ample room for the woofers and tweeter.² The subwoofer will be made in the same way as the Thunder active subwoofer made by North Creek.³ This is by far the best sounding sub I've heard and I've always liked so I decided to make one myself.

Being studio grade monitors, they will be able to recreate the entire spectrum as accurately as possible. With the sub woofer they speakers will be able

¹ Loudspeakers – Pg. 250

² <http://www.northcreekmusic.com/CM-7/CM-7-Tower-Cabinet.PDF>

³ <http://www.northcreekmusic.com/Thunder/ThunderInfo.htm>

to get down to 20Hz. The woofers will take over from 100-200Hz up to 1000Hz. The tweeters will cover from 1000Hz up. All the frequencies will be covered as flat as possible due to my driver selection

While the speakers reach crisp, clear sounds I also want them to look good. The cabinets will be properly constructed and will be a closed box type for the woofer/tweeter cabinet and also a sealed box for the sub. The MDF will be finished with black gloss paint and a clear coat enamel for protection.

These speakers will produce high quality sound from each driver that is sensitive at 90dB. The subwoofer is sensitive at 90dB⁴, the woofers at 88dB⁵ and the tweeter at 95dB.⁶ Due to the tweeters higher sensitivity it will have to be attenuated to match the other two more closely.

Technical Goals

These speakers will be able to pump out high SPL levels but not ridiculously high. With the sensitivities of all the drivers being near 90dB my speakers will produce that SPL at a one meter range, which is where I want my speakers to be spatially compared to me when I mix or make songs. This will be done by

⁴ <http://www.madisound.com/catalog/PDF/peerless/830844.pdf>

⁵ http://www.madisound.com/catalog/PDF/seas/P18RNX_P-H1350-08.pdf

⁶ <http://www.madisound.com/catalog/PDF/neocd3.pdf>

attenuating the tweeter down to 90dB and keeping the other drivers where they are.

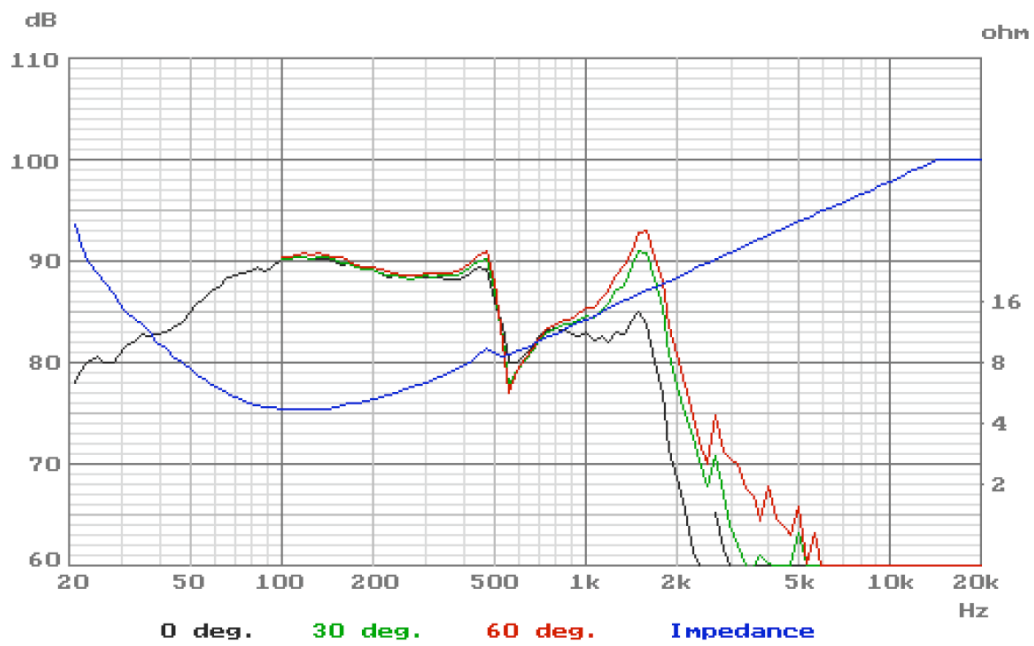
In the endless search of drivers I looked at in this project I came out with only needing to make a three-way system to accomplish what I wanted. I wanted to get a subwoofer that could go all the way down to 20Hz pretty easily and was told that the subwoofer in 212 had a Peerless XLS 12" subwoofer with a passive radiator.⁷ Since this is the subwoofer I wanted to base my own subwoofer off of I chose to go with the same set up never looked back. The XLS I originally picked had a frequency response near 20Hz that was a bit jagged and I then looked at the XXLS sub and it had a much better response in that range so I went with the XXLS over the XLS.⁸⁹

⁷ <http://www.northcreekmusic.com/Thunder/ThunderInfo.htm>

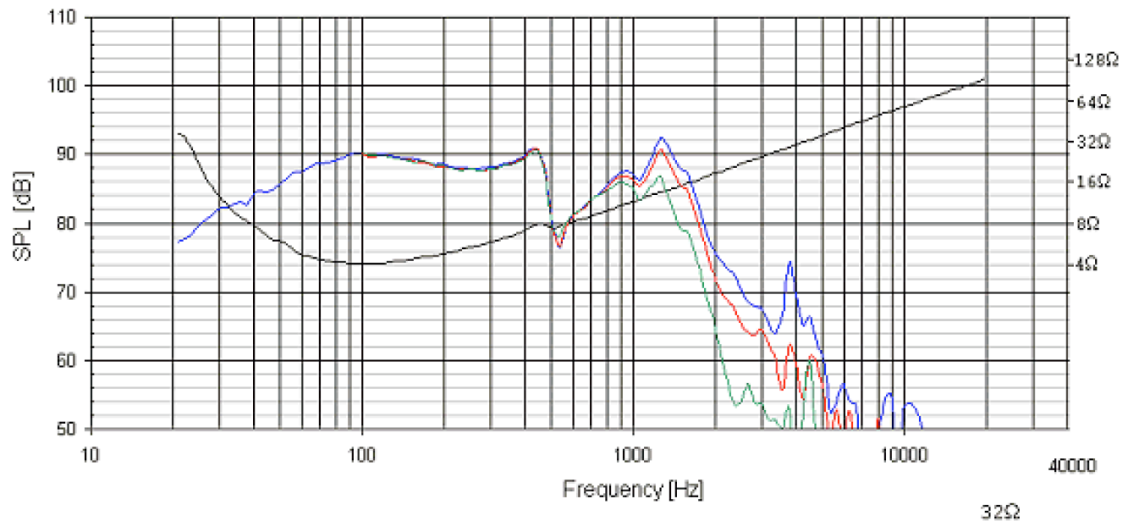
⁸ <http://www.madisound.com/catalog/PDF/peerless/830844.pdf>

⁹ <http://www.madisound.com/catalog/PDF/peerless/830500.pdf>

Peerless XLS



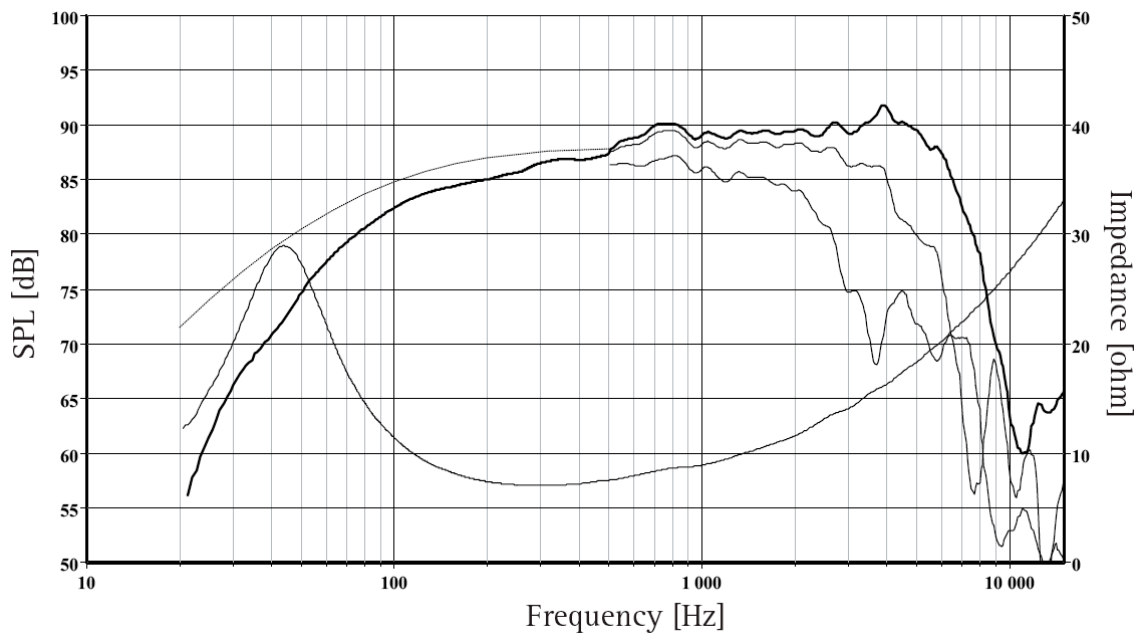
Peerless XXLS



For my woofer/midrange driver I was interested in finding a driver that could get pretty low by it self and still go high into the frequency range while

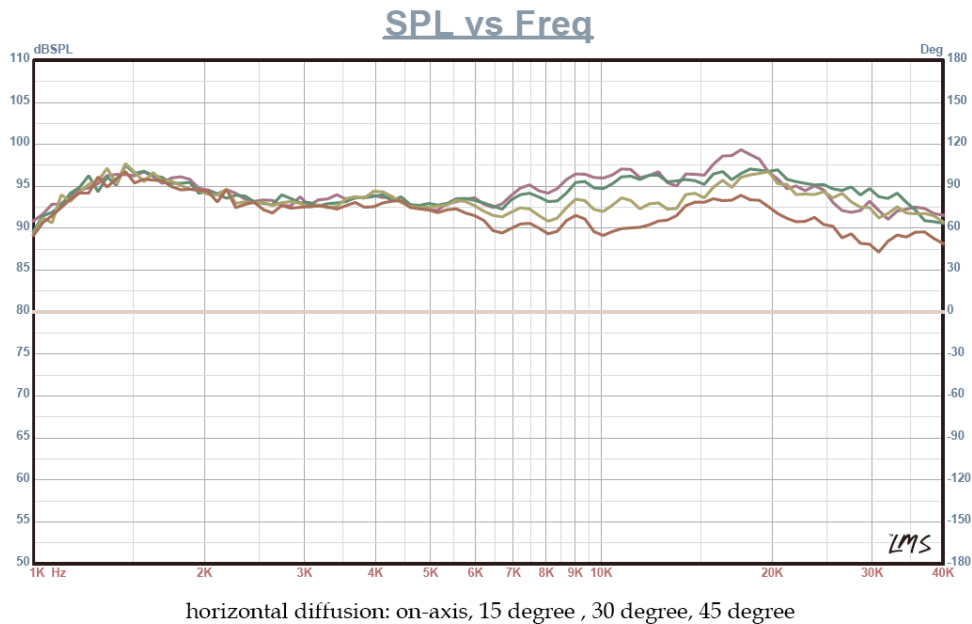
keeping a flat response with little distortion. I looked on madisound and other websites but didn't find anything particularly interesting until I went to zaphaudio. Here they had a list of drivers and peer reviews on them. They rated drivers on their sounds, usability, and consistency. It was here that I fell for the SEAS Prestige P18RNX P 7" Poly Cone Woofer. It has a large magnet for good transient response as well as long copper-clad aluminum voice coil that can travel far and has little distortion. The design around the spider also reduces nice escaping from behind the cone. On top of all that the driver can go from 40Hz up to 2500Hz, which was what I was looking for. The frequency response curve is also really flat up to 1000Hz and get a bit wobbly after but not by reducing output but increasing it.¹⁰

SEAS Prestige 7" Poly Cone Woofer



¹⁰ http://www.madisound.com/catalog/PDF/seas/P18RNX_P-H1350-08.pdf

My search for tweeter was a simple one. I was looking for a nice flat response from a relatively low frequency for a tweeter. I first looked at the Hi-Vi RT1C-A Isodynamic Ribbon tweeter and liked what I saw.¹¹ The response curve looked very nice from 1000Hz and up but I continued looking and came across the Fountek NeoCD3.0 Ribbon tweeter and its response blew the other one out of the water.¹² This tweeter was flat from 1000Hz all the way up to 40,000Hz and I realized this was the tweeter I wanted. It will have to be protected from my active digital crossover like John had to do with his tweeter, but it will make my speakers sound amazing.



¹¹ <http://www.madisound.com/catalog/PDF/hivi/rt1ca.pdf>

¹² <http://www.madisound.com/catalog/PDF/neocd3.pdf>

For my crossovers I wasn't sure where to start. The whole idea very confusing once you start to get into the literature on it. After sifting through pages and pages on it I decided on an three-way active digital crossover network. This being the first time I am ever dealing with building a crossover the task was daunting. I read about them and active had all the perks over passive due the possibilities that active gives you, not to mention the longevity. ¹³An active system allow you to power each set of speakers on it's own amp which promotes flexibility as well as gives you the option to change settings on the fly. I took it one step further and went for a digital crossover that will: a) allow me to change delay and filter settings depending on the room I end up in and b) keep the human element of error out of my design. I've chosen the same crossover as John did due to its functionality and price. I will be using the Behringer Ultradrive Pro DCX2496.

My crossover points will be based on the figure below from *Introduction to Loudspeaker Design*. It shows the suggested crossover points for drivers dependent on their diameter. My subwoofer will be a 12" driver so my crossover should be below 863Hz. This is far to high to go from stereo to mono sound. I will crossover at 100 Hz to allow for the bass to seem to come from the main left and right speakers. The crossover between my 7" SEAS driver and my tweeter should be no higher than

¹³ Loudspeaker Cookbook – Pg 167

1730Hz.¹⁴ I will crossover at 1500Hz to allow adequate room for both the tweeter and woofer to sum and take advantage of the nice responses from both drivers at that frequency.

Nominal Driver Diameter	Conservative Upper Limit	Highest Recommended Frequency
18"	576 Hz	1.14 kHz
15"	720 Hz	1.48 K
12"	863 Hz	1.73 K
10"	1079 Hz	2.16 K
8"	1.23 K	2.46 K
6"	1.73 K	3.46 K
5"	2.16 K	4.32 K
4"	2.88 K	5.76 K

My amplifiers will be an Alesis RA150 to power the tweeter. This amp has 50W of power in stereo, which provides headroom over my 17W nominal tweeters. A Crown 602 will drive the 7" woofers in stereo mode. This amp provides 300W a channel and my woofer have a short term RMS of 250W and a nominal of 80W, providing a ton of headroom. The subwoofer is driven by a Crown 402, which is set to bridged mono. Since the sub needs to be powerful, the amp will provide a whopping 900W in bridged mono, which is more than enough to drive the sub at 100W nominal.

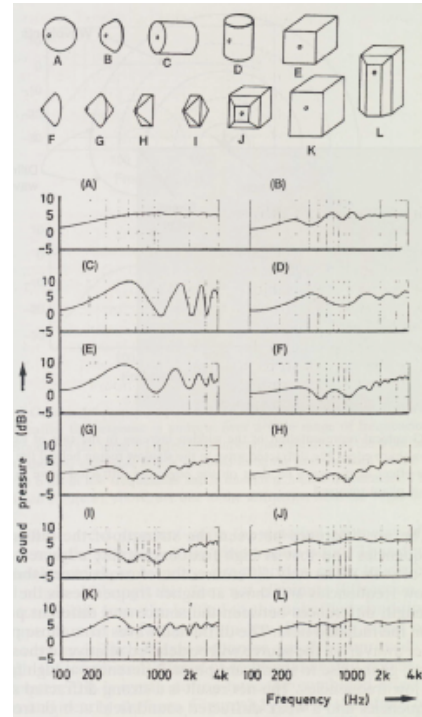
For my cabinet design I originally wanted to build a case similar to case "L" in the image below.¹⁵ This design offers the flattest response across the spectrum but

¹⁴ Intro to Loudspeaker Design – Pg 109

is also difficult to build. I'm not proficient in my woodworking skills and am not willing to make a case with compact angles wrong and have the sound suffer in the process. I will instead follow the case instructions for the Thunder sub as it is displayed. The case is the type of look I want for my speakers, and since I'm not good with woodworking it will be easier to follow a pre-made set of instructions.¹⁶

Similarly I will base the other two cabinets off of the CM-7 Tower case instructions.¹⁷ I like the idea of creating a taller tower to reach up and above the back of a desk while placing the speakers

behind the desk since this is most likely where my speakers will end up. I want to bring the height up to 4 feet and keep the width and depth and get rid of the port since it will not be needed to extend bass.



¹⁵ Loudspeakers – Pg 89

¹⁶ <http://www.northcreekmusic.com/Thunder/ThunderInfo.htm>

¹⁷ <http://www.northcreekmusic.com/CM-7/CM-7-Tower-Cabinet.PDF>

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