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FA 4740
Design Statement 1

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1. Design Concept

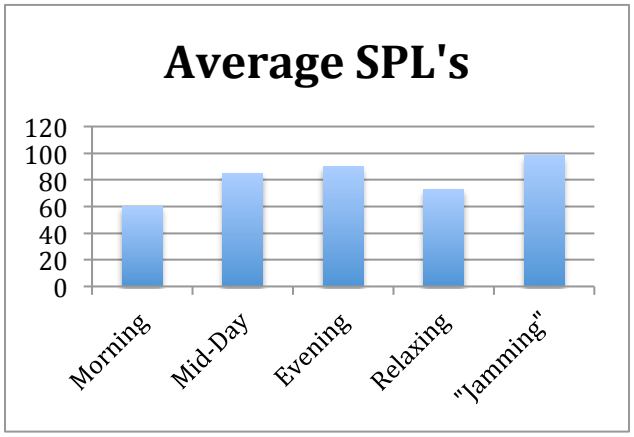
I will be building a two-way loudspeaker system with a separate subwoofer. This system will be for my personal use and will serve as an easy listening system for musical enjoyment. I am fine with the speakers having their coloration (warm, audible depth, smooth…) because they won't be used for critical listening. These speakers will have good depth localization, and a spaciousness that represents sound beyond the speaker's enclosure. With the addition of the subwoofer, I will be able to extend the frequency response for a complete and spatially interesting experience.

On the technical side, I plan to make my system efficient with wide bandwidth capabilities. My tweeters and woofers will be well matched. They will also have to ability to function well in smaller, closed cabinets. By carefully selecting these drivers, my crossover components, and cabinet design I feel that I can achieve this concept.

2. Technical Goals

A. SPL, Volume, and Bandwidth

The SPL that I would like this system to achieve is 90 dB, with a max of 105 dB. I listen at a range of 60-85 dB at a distance of one meter, and 85-95 at a distance of three or more meters. I listen



to many different genres of music, so a system that can cater to these different styles and their relative mixed volume levels is important.

This system will be used mainly for musical listening, so it's bandwidth should extend to cover all frequencies that help reproduce the quality of most songs. My target range is 25Hz-17,000Hz. The f3 of my subwoofer should be around 20 Hz to ensure quality low-end extension.

3. Driver Selection

A. Mid-Range Woofer

Woofer	Sensitivity	Power	X max	Vas	Qts	Fs	Price
1. Peerless 830656 5.25"	84.5	60	3.46	8.77	0.59	57	$18.20
2. Peerless PPB 830860 5.25"	85.8	50	3.5	8.41	0.47	62	$43.30
3. Scanspeak Classic P13WH00-08 5" Poly Cone	88	6.3	?	10	0.33	60	$76.20
4. Scanspeak Disc. 15W/4434G-00 5.25"	89.7	60	8	12.8	0.21	43	$70.70
5. Scanspeak 15M/4624G Disc. 5.25"	92.4	75	8	3.7	0.43	100	$71.20
6. SEAS Prestige CA15RLY 5.5" Paper Cone	87.5	60	10	14	0.34	44	$69.00
7. Vifa NE149W-04 5.25"	87.4	60	5	8.73	0.3	50	$150.40
8. SB Acoustics SB15NRXC30-4 5"	91	50	10	16.7	0.29	41	$55.50
9. SB Acoustics SB15MFC30-8 5"	87	50	10	17	0.36	39	$57.65
10. Accuton C153-8-082 5" Ceramic Cone	89	100	5	32	0.2	31.8	$189.00
11. Markaudio Alpair-10 6"	87	35	8.5	28.1	0.35	35	$110.00
12. Tang Band W5-704D 5.25"	88	28	3.3	11.6	0.38	55	$29.80

After dissecting the table above, mostly based on price, I narrowed my woofer choices down to numbers **6**, **8**, and **9**. I felt that they had the best balance of sensitivity, Vas, Qts, and Fs that I was looking for. I've included the spec. sheets of the three woofers, as well as their frequency responses.

I. SEAS Prestige 5.5"

Nominal Impedance	8 Ohms	Voice Coil Resistance	5.6 Ohms
Recommended Frequency Range	50 - 4000 Hz	Voice Coil Inductance	0.82 mH
Short Term Power Handling *	250 W	Force Factor	5.5 N/A
Long Term Power Handling *	60 W	Free Air Resonance	44 Hz
Characteristic Sensitivity (2,83V, 1m)	87.5 dB	Moving Mass	7.7 g
Voice Coil Diameter	26 mm	Air Load Mass In IEC Baffle	0.42 g
Voice Coil Height	16 mm	Suspension Compliance	1.7 mm/N
Air Gap Height	6 mm	Suspension Mechanical Resistance	1.19 Ns/m
Linear Coil Travel (p-p)	10 mm	Effective Piston Area	80 cm^2
Maximum Coil Travel (p-p)	20 mm	VAS	14 Litres
Magnetic Gap Flux Density	1.1 T	QMS	1.88
Magnet Weight	0.42 kg	QES	0.42
Total Weight	1.29 kg	QTS	0.34

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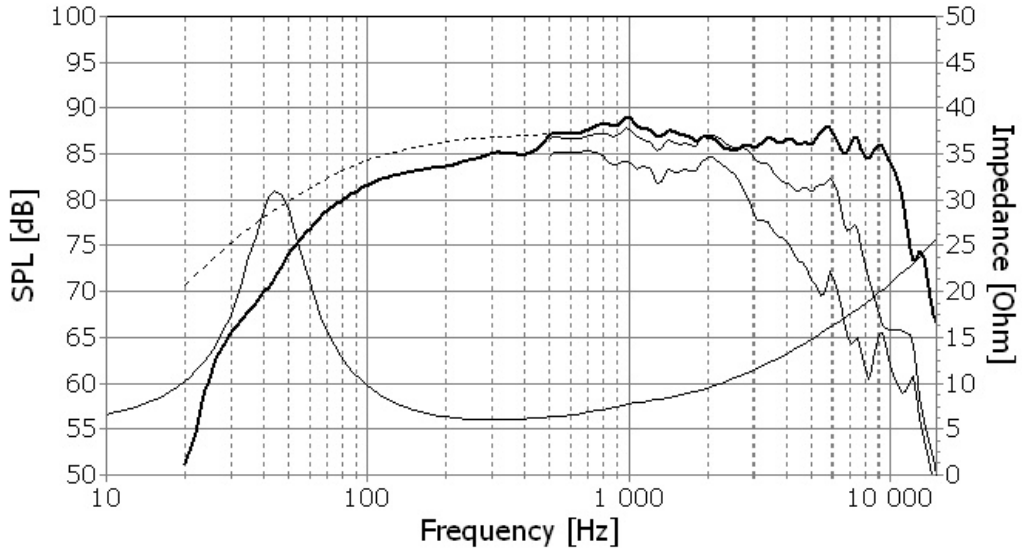
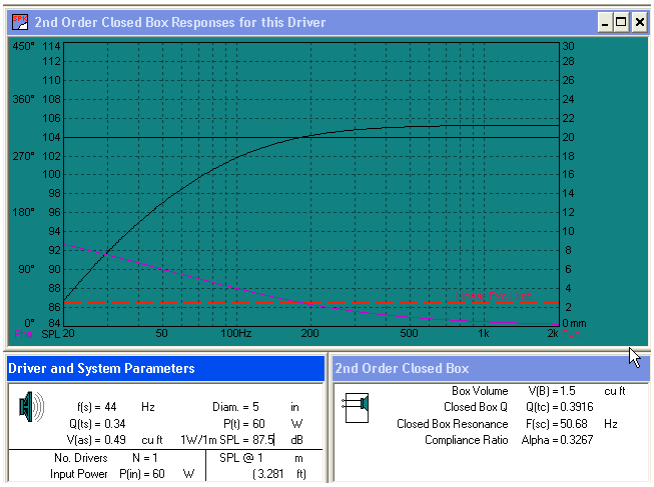


[1] Madisound Speaker Components, www.madisound.com



II. SB Acoustics SB15NRXC30-4 5”

MIDWOOFERS

5" SB15NRXC30-4

Specs :

Nominal Impedance	4 Ω	Free air resonance, Fs	41 Hz
DC resistance, Re	3.1 Ω	Sensitivity (2.83 V / 1 m)	91 dB
Voice coil inductance, Le	0.12 mH	Mechanical Q-factor, Qms	5.3
Effective piston area, Sd	82 cm^2	Electrical Q-factor, Qes	0.31
Voice coil diameter	30.5 mm	Total Q-factor, Qts	0.29
Voice coil height	15 mm	Moving mass incl.air, Mms	8.6 g
Air gap height	5 mm	Force factor, Bl	4.7 Tm
Linear coil travel (p-p)	10 mm	Equivalent volume, Vas	16.7 liters
Magnetic flux density	1.0 T	Compliance, Cms	1.75 mm/N
Magnet weight	0.54 kg	Mechanical loss, Rms	0.42 kg/s
Net weight	1.48 kg	Rated power handling*	50 W

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

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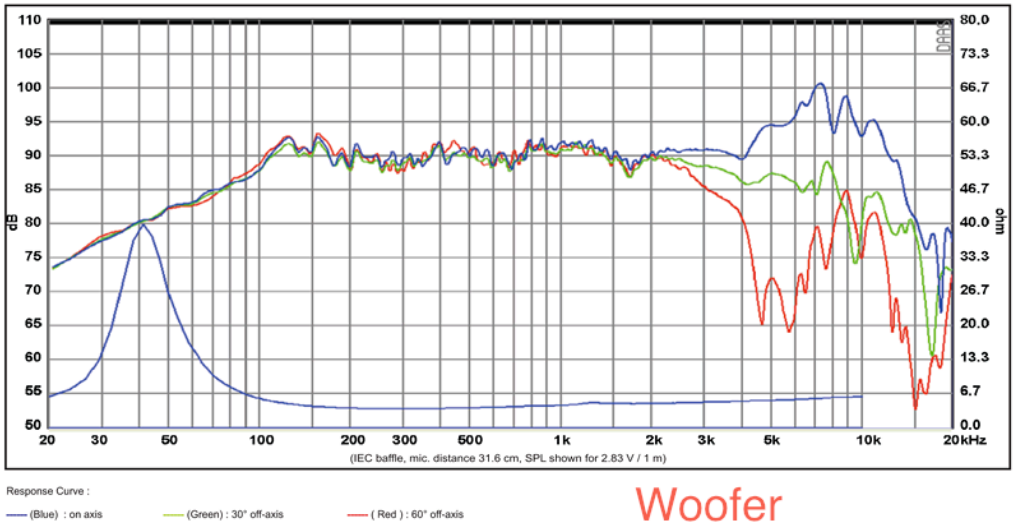


[2] SB Acoustics, www.sbacoustics.com

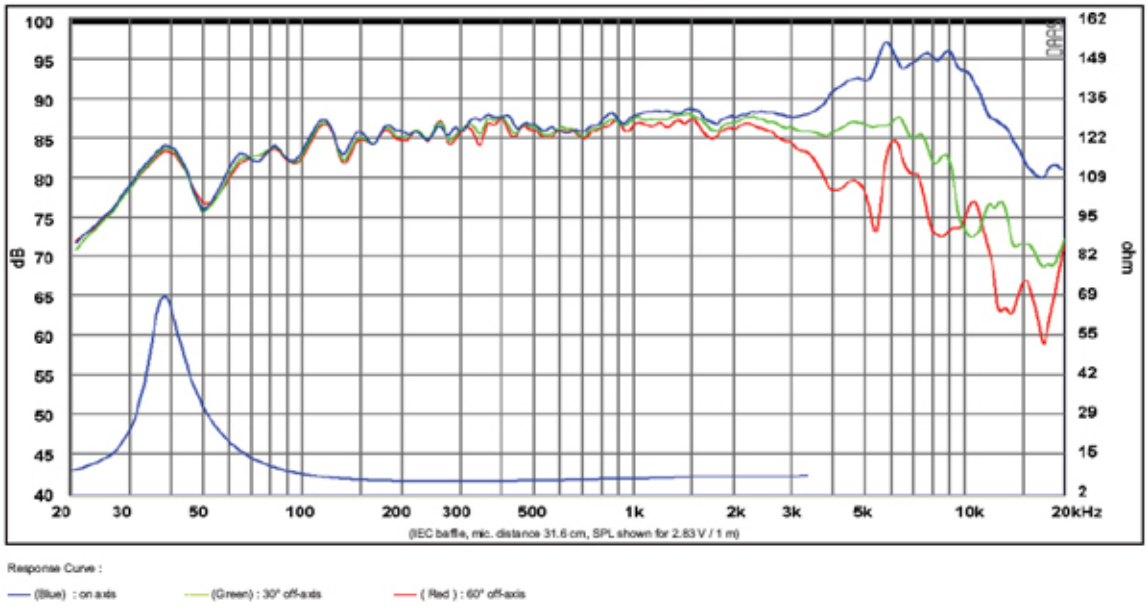
III. SB Acoustics SB15MFC30-8 5”

Specs :

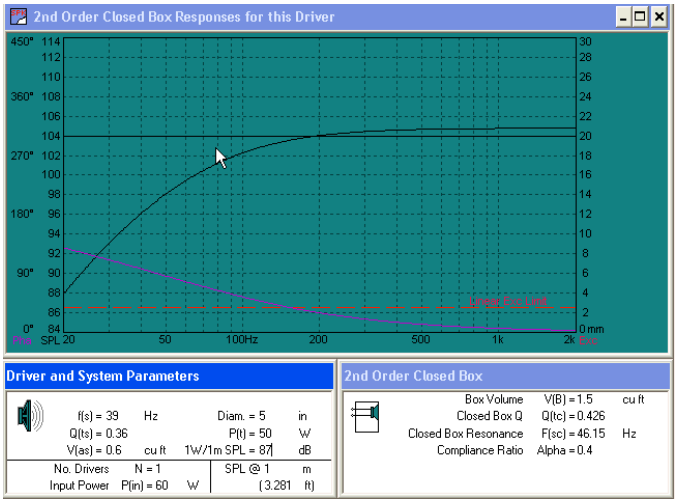
Nominal Impedance	8 Ω	Free air resonance, Fs	39 Hz
DC resistance, Re	5.7 Ω	Sensitivity (2.83 V / 1 m)	87 dB
Voice coil inductance, Le	0.14 mH	Mechanical Q-factor, Qms	4.4
Effective piston area, Sd	82 cm^2	Electrical Q-factor, Qes	0.4
Voice coil diameter	30.5 mm	Total Q-factor, Qts	0.36
Voice coil height	15 mm	Moving mass incl.air, Mms	9 g
Air gap height	5 mm	Force factor, Bl	5.6 Tm
Linear coil travel (p-p)	10 mm	Equivalent volume, Vas	17 liters
Magnetic flux density	1.0 T	Compliance, Cms	1.84 mm/N
Magnet weight	0.54 kg	Mechanical loss, Rms	0.5 kg/s
Net weight	1.48 kg	Rated power handling*	50 W

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

[3]



[3] SB Acoustics, www.sbacoustics.com



I modeled these three speakers in two different alignments: SC_4 and BB_4. I calculated the V_B, f_B, and f_3 values providing that Q_L=3.

SEAS Prestige 5.5" SC4 Alignment: V_B=7.61 f_B=49.72 f_3=67.76

SB Acoustics SB15NRXC30-4 5" SC4 Alignment: V_B=6.19 f_B=44.69 f_3=82.82

SB Acoustics SB15MFC30-8 5" SC4 Alignment: V_B=11.04 f_B=43.68 f_3=54.6

SEAS Prestige 5.5" BB4 Alignment: V_B=8.24 f_B=44 f_3=70.84

SB Acoustics SB15NRXC30-4 5" BB4 Alignment: V_B=6.87 fB=41 f_3=85.69

SB Acoustics SB15MFC30-8 5" BB4 Alignment: V_B=11.4 f_B=39 f_3=56.94

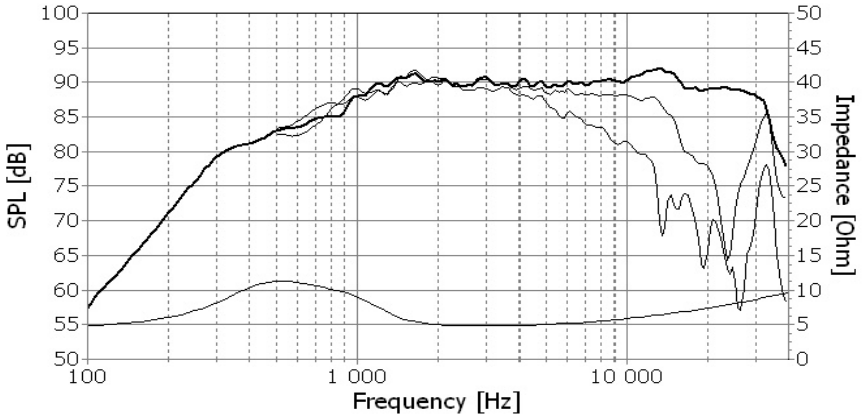
After looking over these results, I have decided to use the **SB Acoustics SBNRXC30-4 5"** woofer. Of the three woofers it has the ability to be enclosed in the smallest cabinet. Although it has the highest f_3 value, its roll off is very smooth on the frequency response graph. I really like the speaker's higher sensitivity as well.

B. Tweeter

Tweeters	Sensitivity	Power	Fs	F3	Price
1. Hi-Vi 1" Fabric Dome	92	15	800	1100	$13.80
2. Vifa BC25TG15-04 1" Textile Dome	87.8	50	1130	1500	$17.00
3.Vifa BC25SC06-04 1" Textile Dome	91.5	25	1390	1200	$19.80
4. SEAS Excel T25CF-002 Millenium	89	90	500	1000	$232.10
5. SEAS Prestige 27TAFNC/G 1"Alum Dome	90	90	1170	1000	$33.35
6. SEAS Prestige 27TDC Textile Dome	90	55	550	1000	$41.90
7. SB Acoustics SB26STAC-C000-4 1"	91.5	120	750	650	$43.85
8. SB Acoustics SB25STC-C000-4	91	120	680	600	$39.95
9. Scanspeak Disc. D2606/9200 1"	91.4	100	1100	1000	$36.65
10. Scanspeak Disc. R2604/8320 1"	90	100	500	700	$54.45
11. Scanspeak Classic D2905/9300 1"	90	150	650	1000	$122.55
12. Dayton Audio DC25T-8 1" Titan. Dome	93	50	1659	1600	$17.75

Looking at this table, I first eliminated tweeters **4** and **11** because of price. I then eliminated **2**, and **12** because their sensitivities were the farthest from the sensitivity of the woofer I chose. The resonant frequencies of tweeters **1**, **3**, **5**, **7**, and **9** are all higher so I cut those as well. My final three were the **SEAS Prestige Textile Dome** tweeter, **SB Acoustics SB25STC-C000-4**, and the **Scanspeak Discovery R2604/8320**.

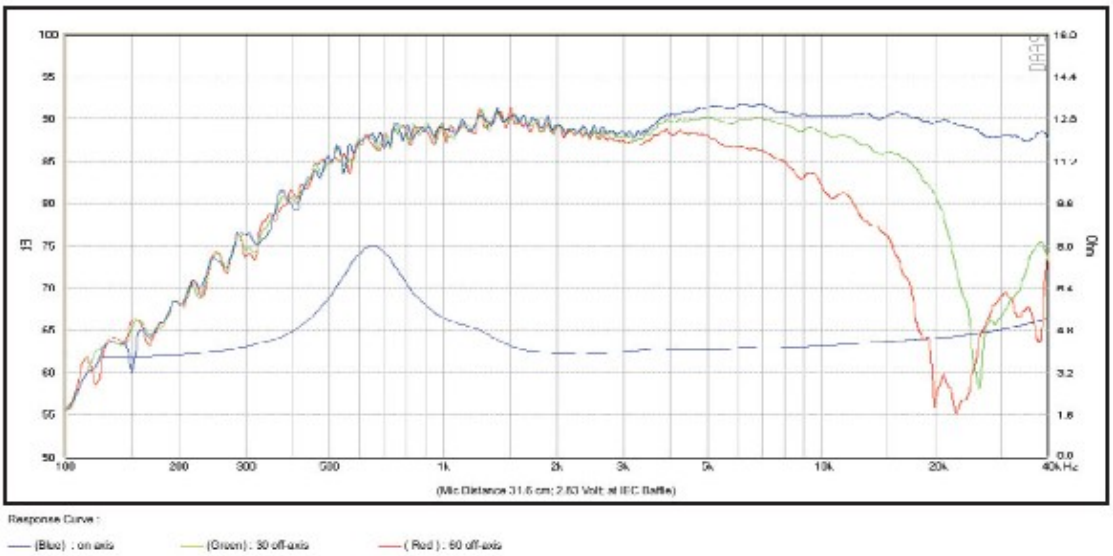
I. SEAS Prestige Textile Dome



[4]

[4] Madisound Speaker Compenents, www.madisound.com

II. SB Acoustics SB25STC-C000-4



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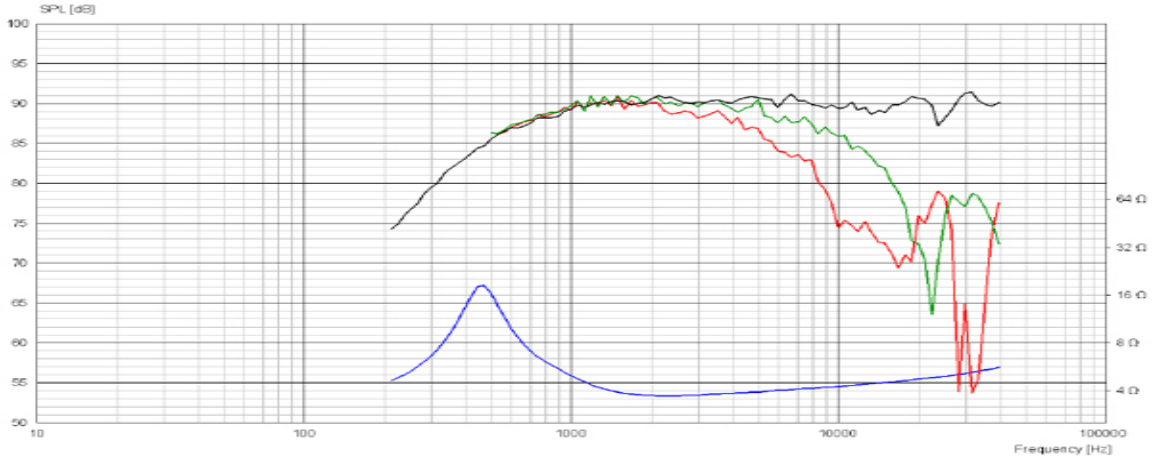
III. Scanspeak Discovery R2604/8320



[6]

After studying the frequency response graphs and the values in the table, I have decided to use the SB Acoustics Tweeter. The SEAS and SB tweeters both have

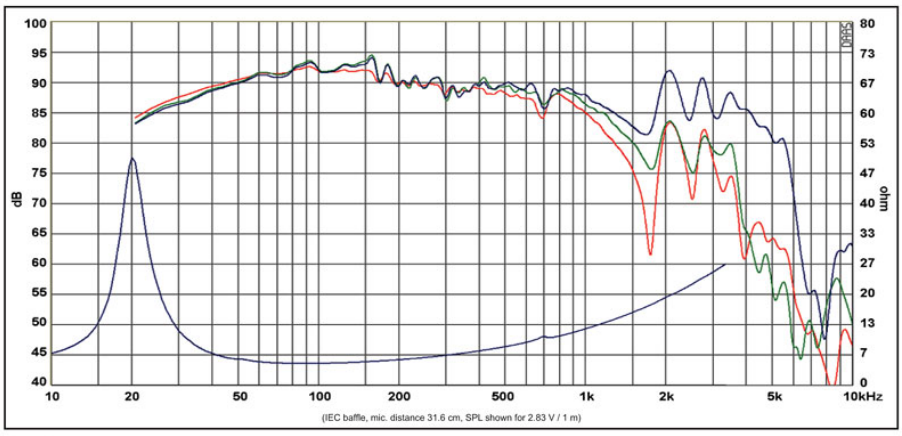
[5] SB Acoustics, www.sbacoustics.com
[6] Madisound Speaker Components, www.madisound.com

similar high-end roll offs but the scaling of the SB graph seems truer, thus showing the roll off to be more gradual. The Scanspeak's different axis' vary too much, and it doesn't have as low of an f3 value as the SB Acoustics tweeter. The tweeter from SB Acoustics is perfectly matched to the mid-range driver in sensitivity. The frequency response has a very smooth roll off, and on axis it theoretically breaks up above 40k. This will give me a clean, full sound.

C. Subwoofer

I. **SB Acoustics SB34NRX75-6 12"**

My subwoofer will utilize a 12-inch SB Acoustics woofer. It is from the same company as my mid-range driver, so they should match really well. Their sensitivities are very close, and this woofer's fs value is at 19 Hz; well within listening satisfaction range.



Specs :

Nominal Impedance	6 Ω	Free air resonance, Fs	19 Hz
DC resistance, Re	4.2 Ω	Sensitivity (2.83 V / 1 m)	90 dB
Voice coil inductance, Le	1.8 mH	Mechanical Q-factor, Qms	5.1
Effective piston area, Sd	508 cm^2	Electrical Q-factor, Qes	0.43
Voice coil diameter	75.6 mm	Total Q-factor, Qts	0.40
Voice coil height	28 mm	Moving mass incl.air, Mms	99 g
Air gap height	6 mm	Force factor, Bl	10.7 Tm
Linear coil travel (p-p)	22 mm	Equivalent volume, Vas	260 liters
Magnetic flux density	0.9 T	Compliance, Cms	0.71 mm/N
Magnet weight	2.1 kg	Mechanical loss, Rms	2.3 kg/s
Net weight	5.85 kg	Rated power handling*	200 W

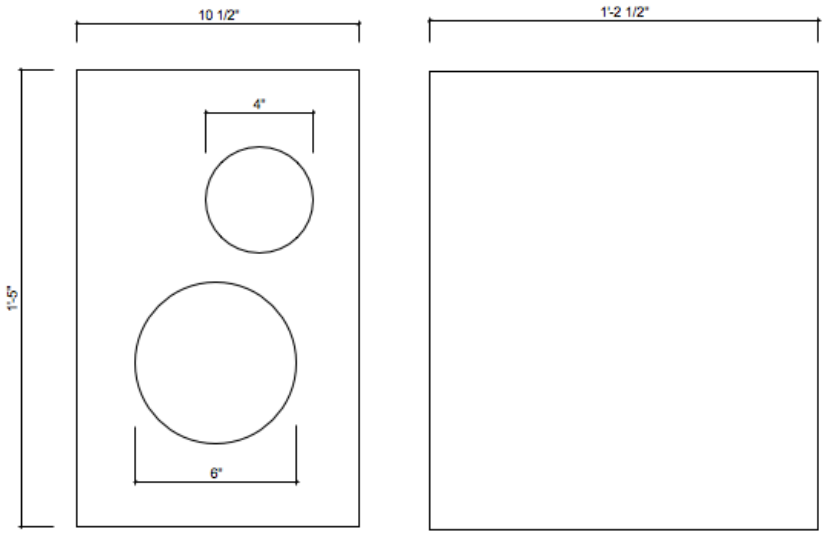
4. Cabinet Construction

A. Cabinet Type

Both the stereo pair and the subwoofer will be closed cabinets. With the use of the subwoofer, I don't feel the need to port the speakers because the sub will help reproduce any low frequencies that will occur. The speakers will be rectangular in shape, with a box inside of a box construction design.

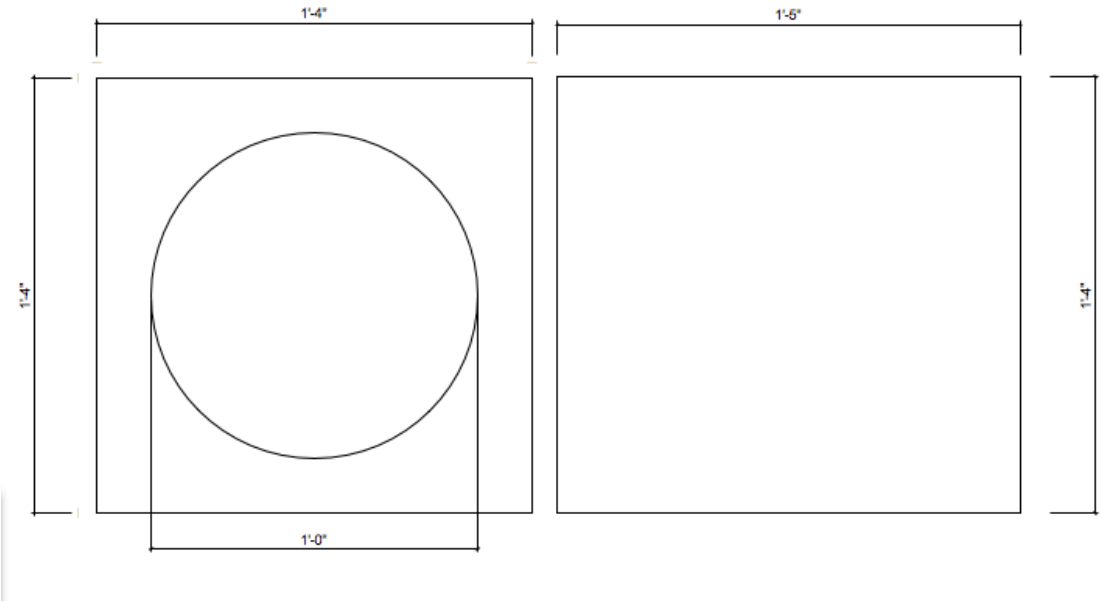
B. Size

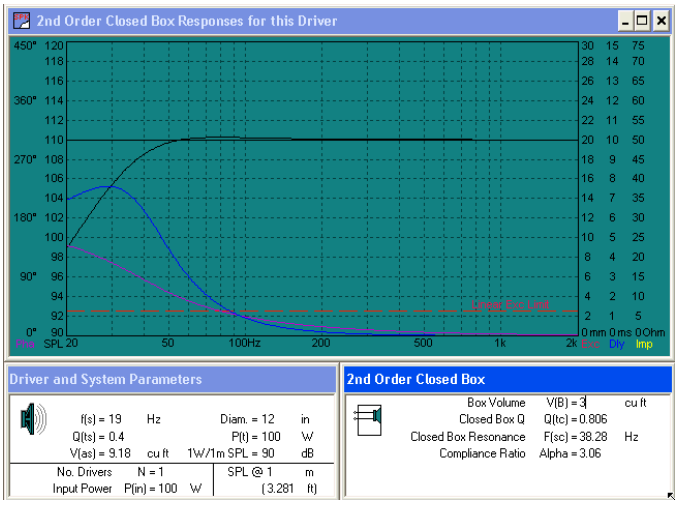
Originally I thought that I wanted to make smaller speakers, along the lines of 14 in. (height) by 8 in. (width) by 12 in (deep). After researching cabinet sizes I have decided that increasing these measurements would help me to avoid major problems like low frequency response inaccuracies[7], and overheating the voice coils[8]. I have expanded my desired dimensions, but will still be able to keep the overall size of the speakers small with the use of my subwoofer.



[7] Philip Newell and Keith Holland, *Loudspeakers: For Music Recording and Reproduction* (Burlington, MA: Elsevier, 2007), 320.
[8] Newell and Holland, *Loudspeakers*, 326.

The subwoofer needs to fit under my desk. The suggested enclosure for the SB34NRX75-6 subwoofer is 2.6 feet cubed. That is roughly 16.8 inches for each dimension if one were to build a cubed enclosure. After modeling my subwoofer in WynSpeaker I decided to go with the dimensions 16 x 16 x 17 inches.



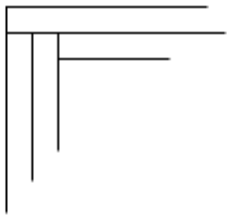


C. Driver Placement and Diffraction

To help eliminate diffraction at its source, I plan to offset my tweeters to avoid the nodes summing and creating large peaks in the frequency response. I will also mount my drivers so that they are flush with the baffle, avoiding sharp edges that will add diffraction.

D. Bracing

My cabinet design is a box in a box; so working with this design I will use the two layers to create a dado joint. The outer layer will be ¾" birch, and the inner ¾" MDF. To make the enclosure more rigid I will also use corner bracing, which increases the mutual coupling of adjacent walls.



E. Visual Aesthetics

With an outer birch layer, I plan on staining my speakers so that they have a nice wood grain finish. The stain will be warm toned, to match the overall sound of the system. [9]

5. Crossover

A. Crossover Point

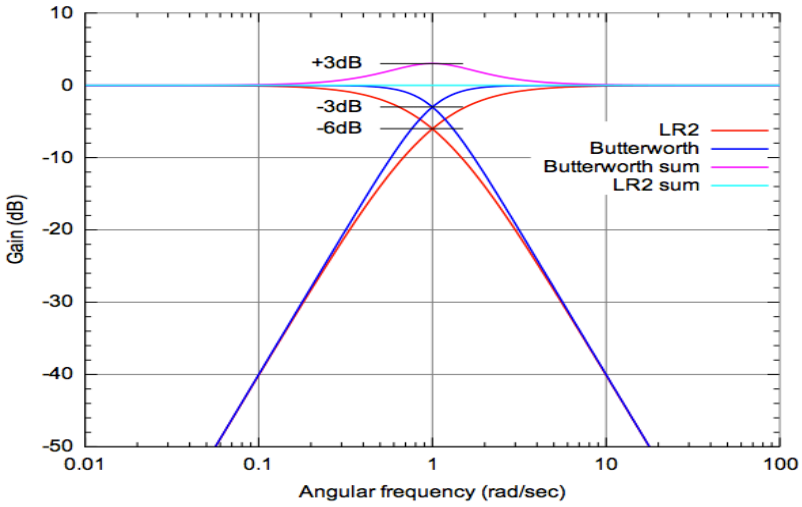
After studying the frequency response graphs of my tweeter and mid-range driver, I have chosen 1,500 Hz as my cross over point. Both drivers experience slight

[9] Orr Bee Supply, http://orrbeesupply.web.officelive.com/naturalhive.aspx

dips in their responses at 1,500 Hz, so I will take advantage of this. A plus of having a lower cross over point is that my speakers will have greater clarity, although a lower output.

B. Topology

I plan to use a passive Fourth-order Linkwitz–Riley crossovers. They are constructed by cascading two 2nd-order Butterworth filters. Their steepness is 24 dB/octave. The phase difference comes to 360°, so the two drives appear in phase. Linkwitz-Riley crossovers also have a flat summed output, whereas Butterworth have a +3dB peak at the crossover. The steep slope increases the SPL output and will help lower distortion from the lower crossover point.[10]



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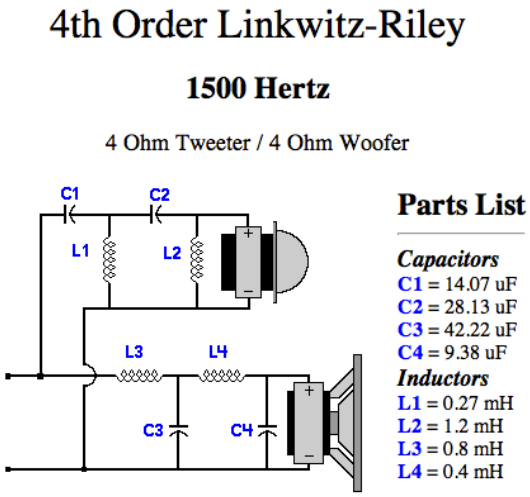

[10] Christopher Plummer, Professor, Sound Design Michigan Technological University
[11] Wikipedia.com

C. Subwoofer Crossover

I will be using a Keiga 200 watt plate amplifier with a built in electronic crossover. The crossover is adjustable and can be turned off as well. This amp has a 50Hz to 100Hz continuously adjustable low pass 12dB electronic crossover. It also has a 4dB boost at 25Hz, which gives me a slight jump above the frequency response of the subwoofer driver.

Specifications: Power output Watt@ 4 ohms: 200 THD: 0.05% S/N ratio @ rated power: 85dB Input sensitivity @ 100Hz - low level: 75mV Input sensitivity @ 100Hz - high level: 3.5V Input impedance: 22k ohms Variable Low Pass Crossover Frequency: 50-100Hz Weight: 10.5 lbs Dimensions W x H inches: 11-7/16 x 8-1/4 Cutout hole W x H inches: 10-7/16 x 7-1/4 AC Voltage: 115[12]

6. Budget

[12] Madisound Speaker Components, www.madisound.com

Initially I wanted to keep my budget to $800 dollars, but with the integration of the subwoofer I feel that it would be a smart move to increase my budget to $900.

A. Prices

Tweeters: 2 @ $39.95

Mid-Range Drivers: 2 @ $55.50

Subwoofer: 1 @ $180.90

Plate Amp: 1 @ $169.00

Total: $542.80

Amount Left: $357.20