Euphony Blues

Design Statement and Tuning Report

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FA 4740: Transducer Theory
Revised May 3, 2013

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Functional Description

Purpose

These speakers will be used for critical listening and mixing at home. The source of the sound will usually be music, but could also be film. This necessitates a frequency response that is flat and also reaches reasonably low, a size and shape that will fit on a desk or shelf, and characteristics that will allow the speakers to sound good in a small room. They will be for "listening backwards"[1] to hear the most faithful possible reproduction of the original source recording.

Budget

My final budget must not exceed $800. $400-$600 would be preferable.

[1] Moulton. Total Recording: The Complete Guide to Audio Production and Engineering. KIQ Productions, 2000.

Design Goals

Design Priorities

For home mixing purposes, the most important quality of these loudspeakers is their frequency response, followed by their bass response, then size. They must reproduce most of the audible frequency spectrum accurately. The speakers must also be small enough to place on a desk or shelf and fit easily into any car for transportation. SPL is the least important of my major factors, because I tend to mix at relatively low levels, and the speakers will be very near me when I use them. The speakers should also be sturdy for the sake of taking them with me when I move, which may happen frequently over the life of the speakers. However, I would not want to permanently install a grill that would affect the sound.

Bandwidth Goal

To determine my minimum acceptable bass extension, I listened to an assortment of songs from several genres and began cutting the bass, taking note of where the loss became noticeable, significant, and finally unacceptable.

Song	**Genre/Characteristics (describes the section of the song used for judging)**	**Noticeable Bass Loss**	**Significant Bass Loss**	**Unacceptable Bass Loss**
Animal – Miike Snow	Electronic indie pop – thumping bass, one male vocalist	45 Hz	75 Hz	85 Hz
Bad Romance – Lady Gaga	Pop – One female vocalist, thumping bass, electronic sounds	50 Hz	70 Hz	95 Hz
Bangarang – Skrillex	Dubstep – electronic, bass heavy	50 Hz	70 Hz	100 Hz
Dog Days Are Over – Florence and the Machine	Alternative/progressive rock – female vocalist, backing vocals, rich orchestration, thumping bass	50 Hz	70 Hz	95 Hz
For the Girl –	Punk – Distorted electric	55 Hz	75 Hz	95 Hz

The Fratellis	guitar, drums, male vocalists, bass guitar			
For the Widows in Paradise, For the Fatherless In Ypsilanti – Sufjan Stevens	Indie folk – male lead vocalist, two banjos, female background vocals, soft trumpet	55 Hz	75 Hz	90 Hz
Little Black Submarines – The Black Keys	Rock – male vocalist, electric guitar, bass guitar, drums	45 Hz	70 Hz	90 Hz
O Children – Nick Cave and the Bad Seeds	Alternative rock/soul – male lead vocalist, backing choir, drums, piano, bass guitar	60 Hz	85 Hz	110 Hz
Requiem – Mozart	Classical – Full orchestra and choir	60 Hz	95 Hz	110 Hz
Soul to Squeeze – Vitamin String Quartet	String Quartet rendition of a rock song	65 Hz	85 Hz	95 Hz
Video Games – Lana Del Rey	Indie pop – one female vocalist, piano, electronic sounds	60 Hz	85 Hz	100 Hz

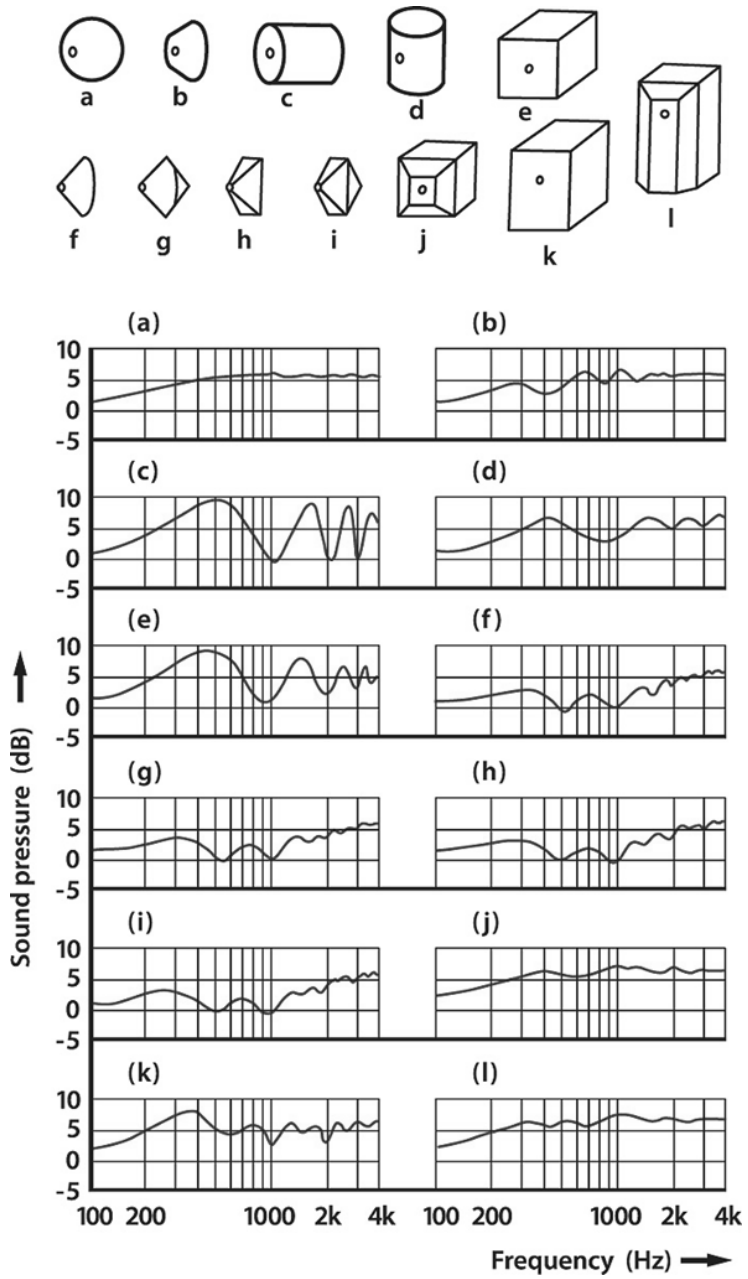
Based on these results, I would like to reach at least 60 Hz with my speakers.

Size, Shape, and Diffraction

The speakers will ideally be desk speakers meant for home mixing. They must be small enough, portable enough, and durable enough to survive several potential relocations. At the very largest, they must not be larger than 16 inches wide, 24 inches tall, and 20 inches deep. To achieve the bass response that I need in a rather small box, the box will be vented.

I will base the shape of my speakers on the Olson study referenced on page 83 of Newell and Holland's *Loudspeakers for Music Recording and Reproduction.*[2]

[2] Newell and Holland, *Loudspeakers for Music Recording and Reproduction,* 83.



Based on these frequency responses, I will be building a speaker that most closely resembles model “l” in the above chart. This will give me the flattest possible frequency response, and the beveled edges will

help to ease the effects of corner diffraction. For easier construction, I will not bevel in the top of the front panel.

SPL Output

SPL is not my main priority, because I mix at low levels within a meter of my speakers. To find my preferred comfortable levels, I listened to a wide variety of music and took note of levels that I enjoyed for low, medium, and high listening or mixing levels. Measurements were made in both dBA and dBC. The full results can be examined in Appendix A, and the average results are as follows in Figure 1.

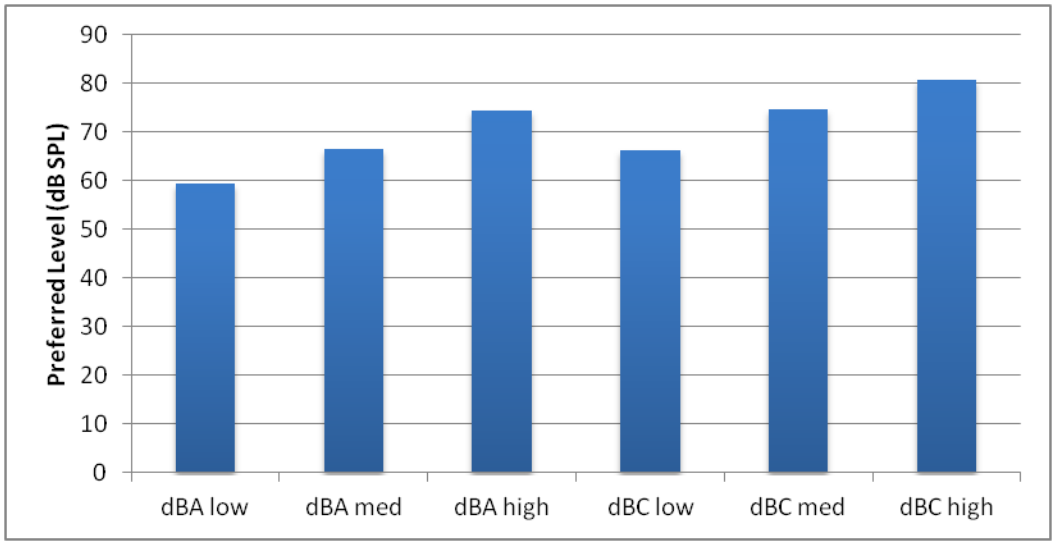


Figure 1: Preferred Listening Levels

Based on these results, focusing on dBA, and accounting for a crest factor of 28 dB[3], my speakers should ideally reach 103 dB. However, the high measurements from this experiment are above levels I would use for mixing. I would be more likely to mix at the low or medium levels, 59 dBA and 67 dBA respectively. Adding the 28 dB crest factor to the medium level gives a more reasonable goal of 95 dB. If 95 dB is still not possible, I will reduce the crest factor to a still-respectable 20 dB, putting my low goal at 87 dB.

[3] Plummer, "FA 4740 Lecture." Houghton, MI, January 28, 2013

Directivity

Off-axis sound will not be a main factor in my design, as the speakers are meant to be listened to while mixing from the same place, right between them. However, directivity will need to be addressed in order to think about how the walls of the room might affect the sound.[4] The "Driver Size and Spacing" section will discuss how I will attempt to avoid sound being directed toward the floor and ceiling and causing ugly early reflections.

Coloration

The design of these speakers should avoid any distinct coloration of the sound. They will need to have a frequency response that is as flat as possible in order to reproduce the source sound as faithfully as possible.

Visual Aesthetics

I would like these speakers to look professional and unique. If it is possible, I will use wood with a nice grain and stain it a deep blue/indigo color. If the wood grain is not attractive or staining becomes too problematic, I will use paint instead.

Construction Materials

I will be using ¾ inch 13-ply Baltic birch because it is sturdy and used for professional speakers,[5] backed by ¾ inch MDF as recommended by the North Creek Cabinet Handbook.[6] The Baltic birch will also help me achieve my aesthetic goals, as it has a pleasant grain and a light color that should take the stain well.

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[4] Moulton. *Total Recording: The Complete Guide to Audio Production and Engineering.* KIQ Productions, 2000.
[5] Plummer, FA 4740 Lecture, Houghton, MI, February 1 2013.
[6] North Creek Music Systems. *North Creek Cabinet Handbook.* Old Forge, NY, 1992.

Technical Details

Baffle Step

The front of my cabinet will not be very wide before the edges bevel in; the front panel will be roughly one inch beyond each side of the woofer. With an 8 inch woofer, the front panel will be about 10 inches. To calculate baffle step, I used the following equation (where W_b is the width of the baffle in feet):[7]

$$f_3 = 380 \,/\, W_b$$

$$380 \,/\, 0.833 \; = 456.000\, Hz$$

Using a 10 inch front panel, the baffle step boost will begin at 456.000 Hz. I will account for this by padding the signal above that frequency.

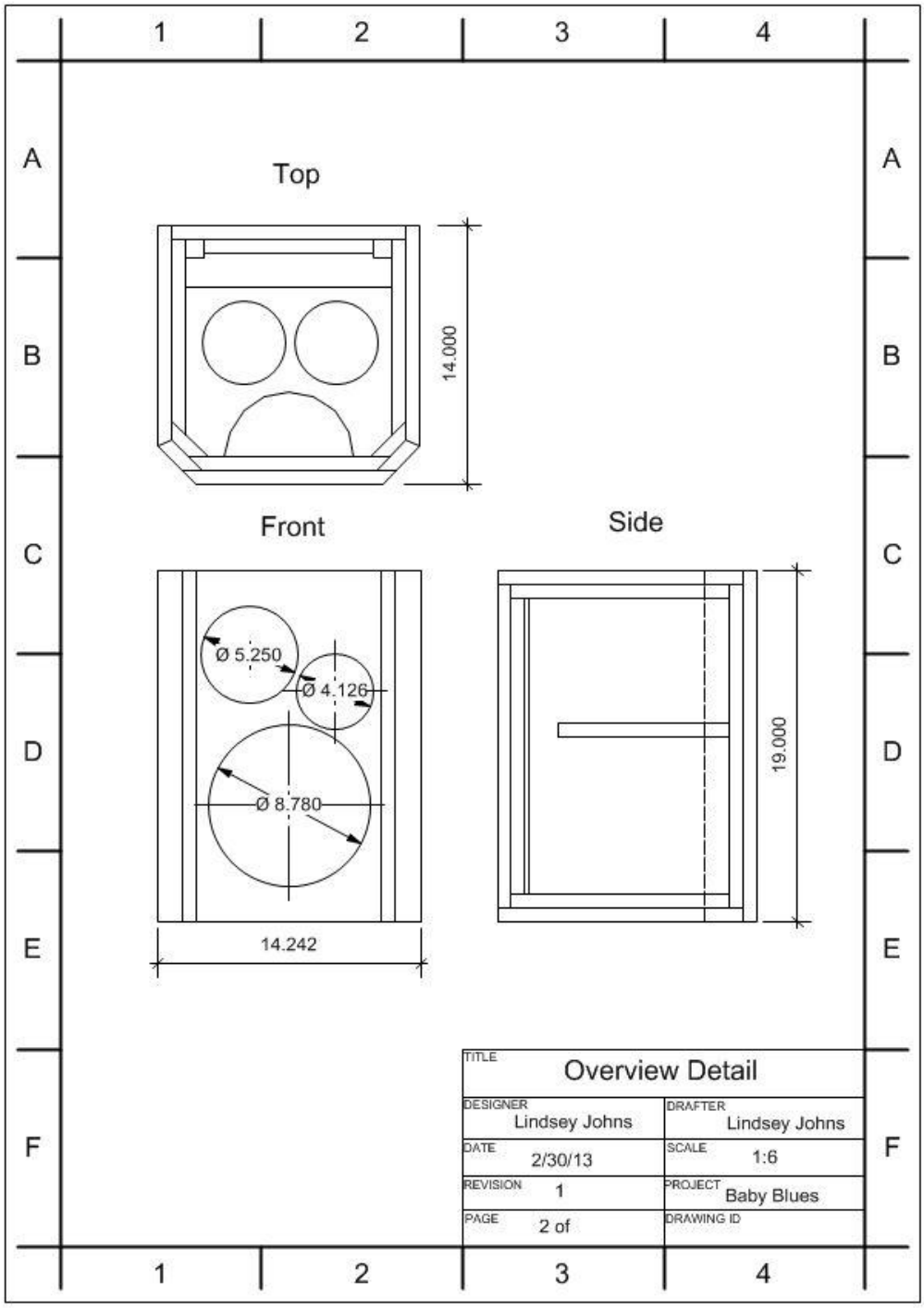
Low Frequency Alignment

I cannot achieve the bass response I need in a small sealed box, so I will sacrifice a small amount of transient accuracy and install a port. To avoid unpleasant early reflections off the back wall coming straight back out the port, the back wall will be lined with Sonic Barrier damping material instead of MDF.

[7] Elliot, *Elliot Sound Products.* December 8, 2001.

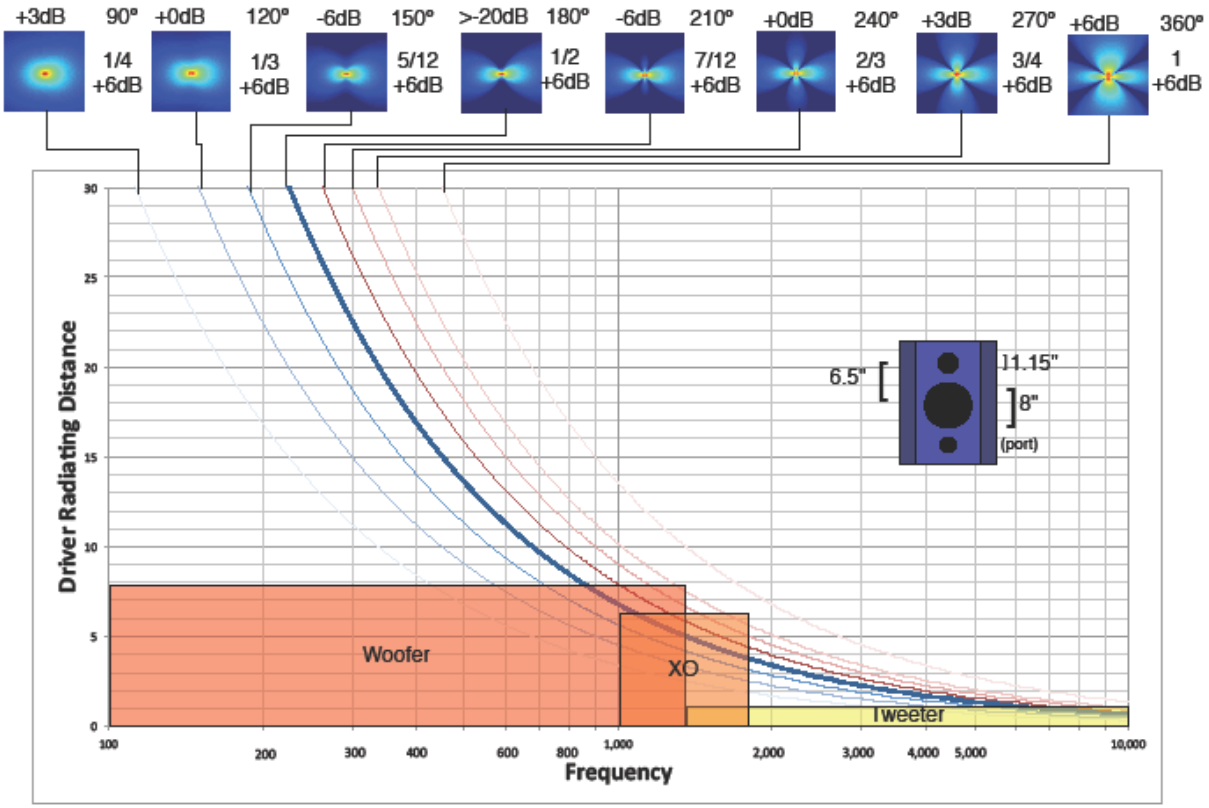
Wall Construction and Bracing

See Appendix B for full drafting details.



Driver Size and Spacing

I will be using a 1 1/8 inch tweeter and an 8 inch woofer. Creating a personal version of a handout designed by Christopher Plummer and handed out in FA 4740,[8] I was able to analyze possible driver distances. My ideal circumstances, as I will want low levels vertically for small-room listening, are 0.5 inches between my woofer and tweeter, with the crossover as close to 1000 Hz as possible. 1200 Hz is my crossover goal, but I may need to raise that to 1400 or 2000.



[8] Plummer, "FA 4740 Lecture." Houghton, MI, January 28, 2013.

Driver Selection

Woofer Analysis and Selection

	U18RNX/P[9]	SB17NRXC35-8[10]	18W/4434G-00[11]	**RS225-8[12]**	DS215-8[13]
Frequency Range* (Hz)	55 - 4000	45 - 3000	50 - 5000	**38 - 2200**	50-2000
Power Handling (W)	80	60	120	**80**	80
Diameter (inches)	7	6.5	7	**8**	8
Sensitivity (dB)	88	89	90.8	**86.2**	90.1
Price ($)	101.10	48.00	73.75	**57.42**	43.20

*Low limit as modeled in Winspeakerz

Woofer #1 Detail – Dayton Audio RS225-8

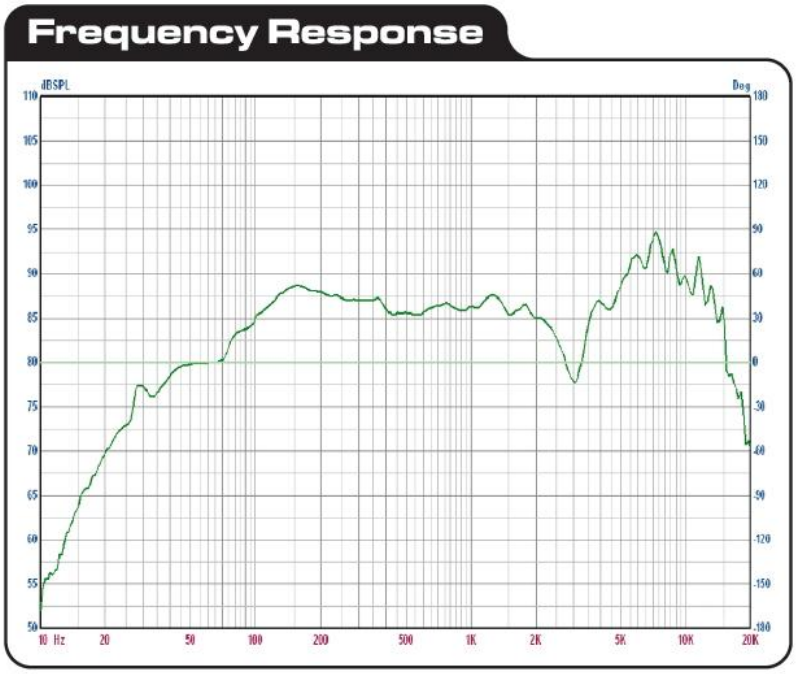
Frequency Range: 38 – 2200 Hz

Power Handling: 80 W

Diameter: 8 in.

Sensitivity: 86.2 dB

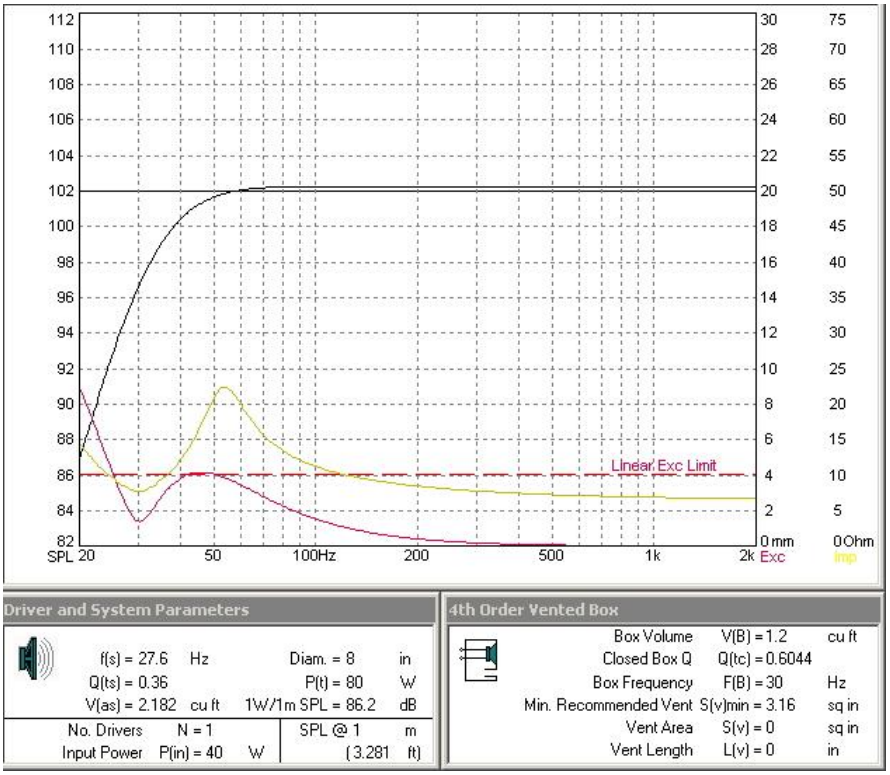
Price: $57.42



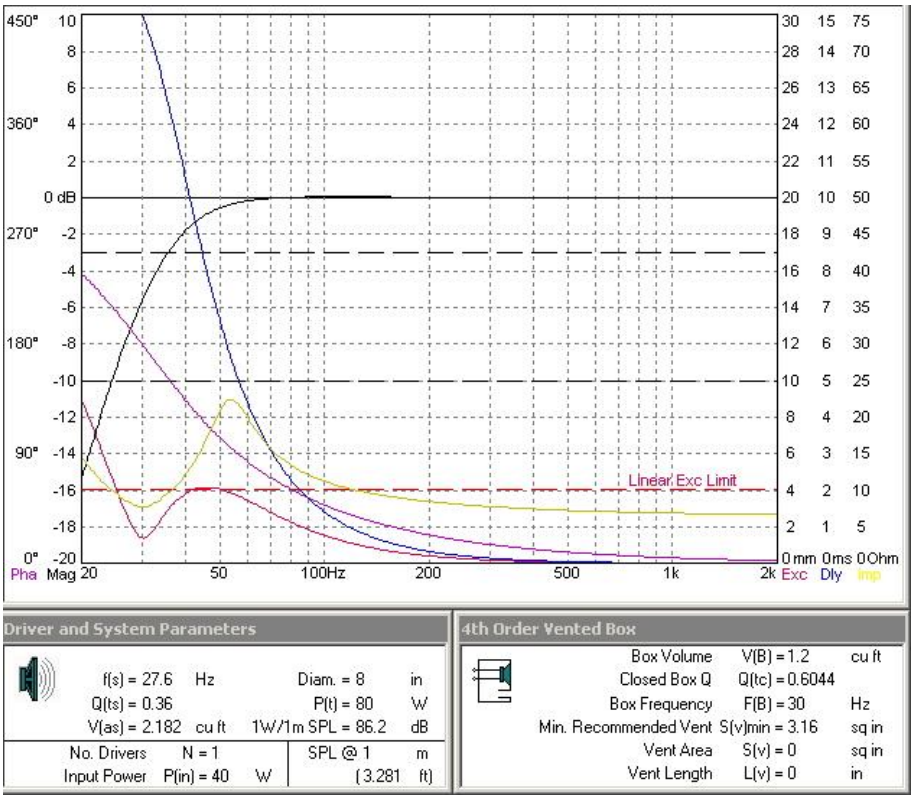
This 8 inch woofer is the one I have chosen for my speakers. It exceeds my bass extension and SPL goals, it has a relatively flat frequency response, it is made of sturdy aluminum, and it is very well-priced. It is built to be low-distortion, and it will work well in my vented box. High frequency ringing will

[9] Seas. "Seas Prestige U18RNX/P (H1571) 7" Curv Cone Woofer." *Madisound Speaker Store.*
[10] SB Acoustics. "SB Acoustics SB17NRXC35-8 6.5" Woofer." *Madisound Speaker Store.*
[11] Scanspeak. "Scanspeak Discovery 18W/4434G-00, 7" Midwoofer, 4 ohm." *Madisound Speaker Store.*
[12] Dayton Audio. "RS225-8 8" Reference Woofer." *Parts Express.*
[13] Dayton Audio. "DS215-8 8" Designer Series Woofer." *Parts Express.*

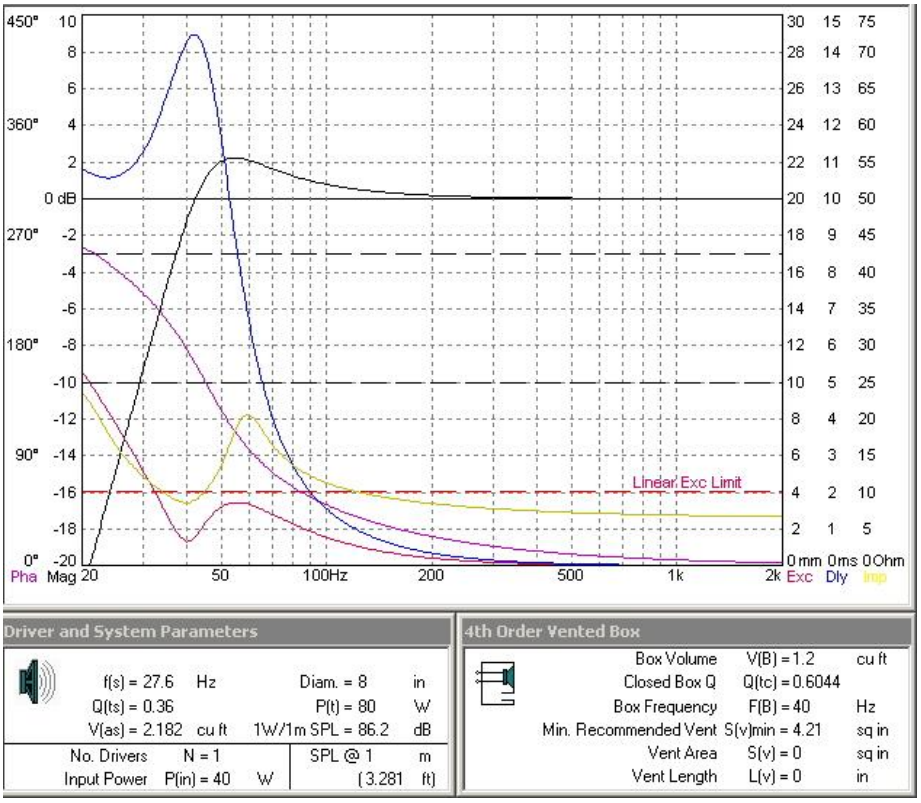
be easily eliminated by a crossover below 3000 Hz.



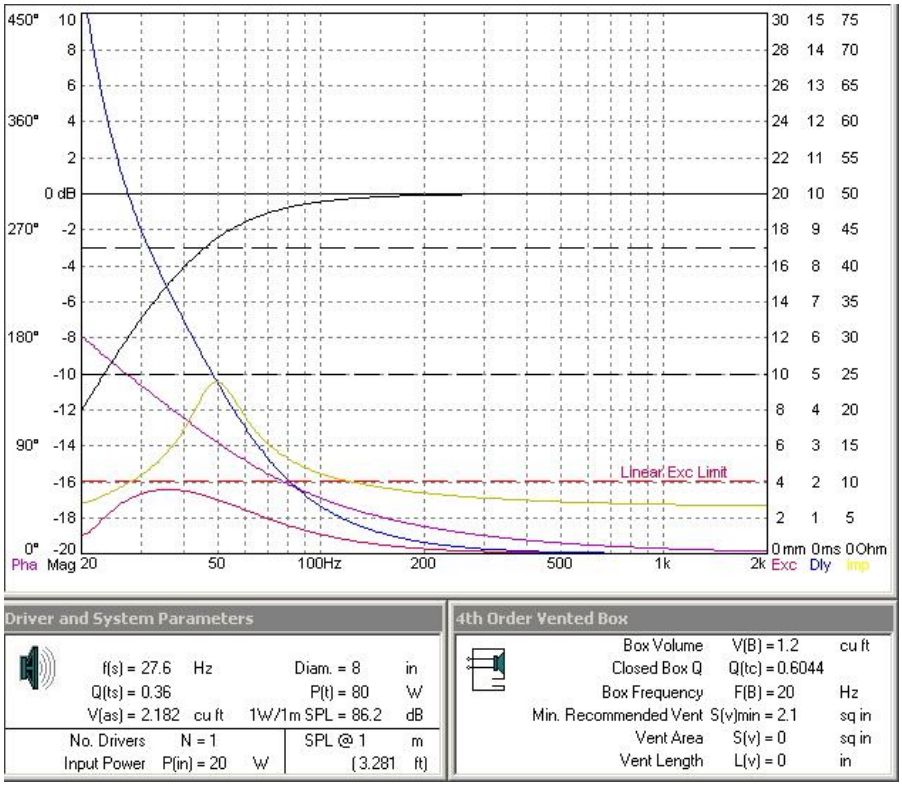
At 80 W, these drivers can reach 102 dB SPL, which is beyond loud enough for my purposes.



By tuning the vented box to 30 Hz, I can achieve a flat response down to about 40 Hz, which is beyond my goal.

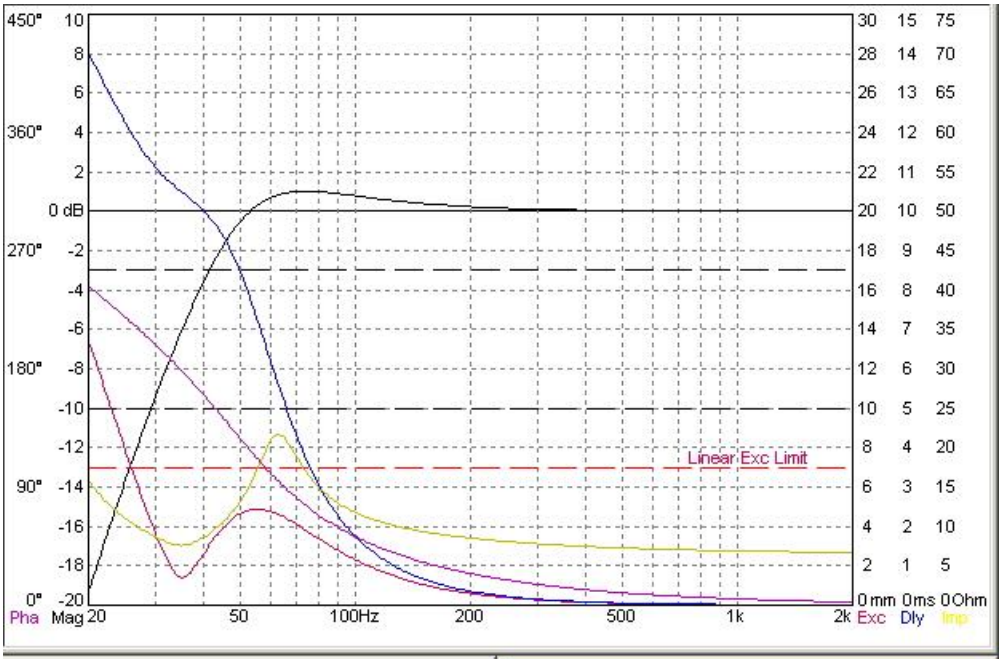


Tuning the box to 40 Hz results in a bass boost at 50 Hz.



Tuning the box to 20 Hz slightly extends the bass response, but causes it to begin rolling off earlier.

Overall, I think this woofer is the best option for my purposes. I modeled it in a smaller box as well, and was able to get more bass than I expected. The figure below shows a great compromise that will allow me to use this woofer to get down to 40 Hz in a box that is only 0.8 cubic feet internally.



Woofer #2 Detail – SB Acoustics SB17NRXC35-8

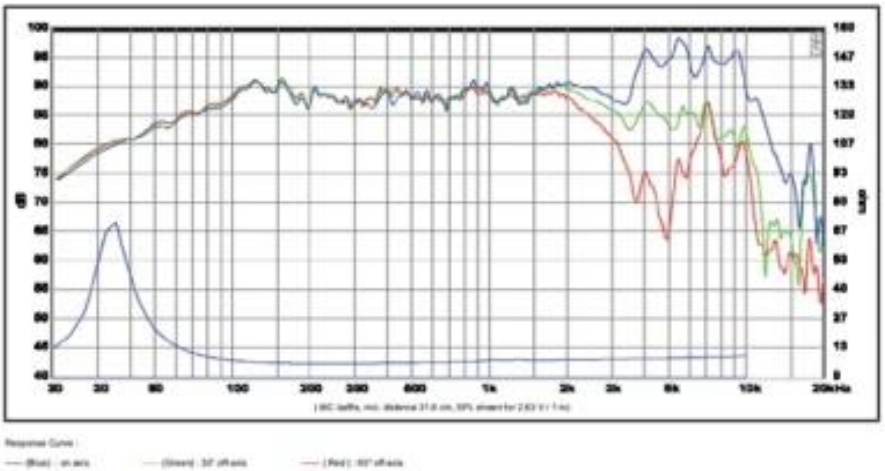
Frequency Range: 45 – 3000 Hz

Power Handling: 60 W

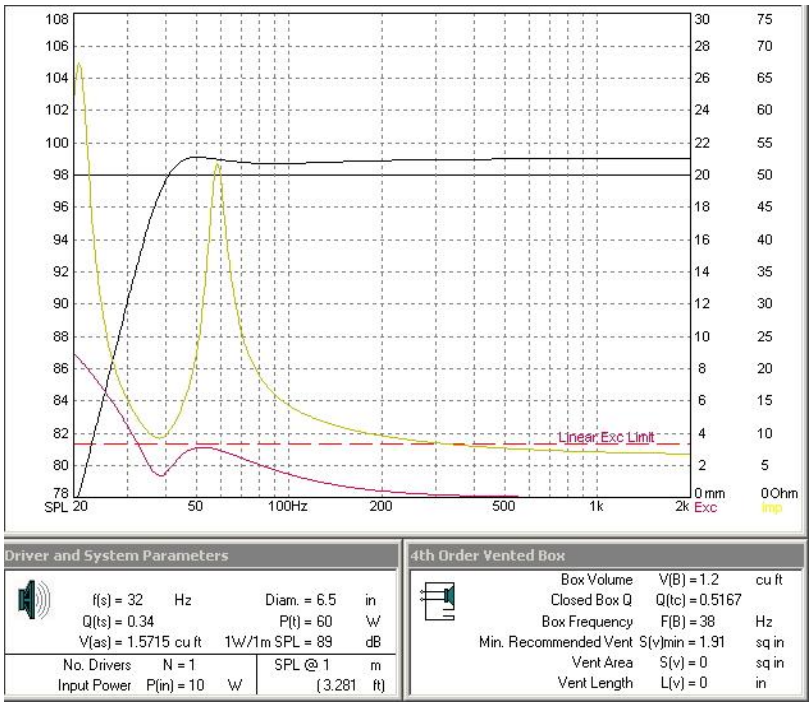
Diameter: 6.5 in.

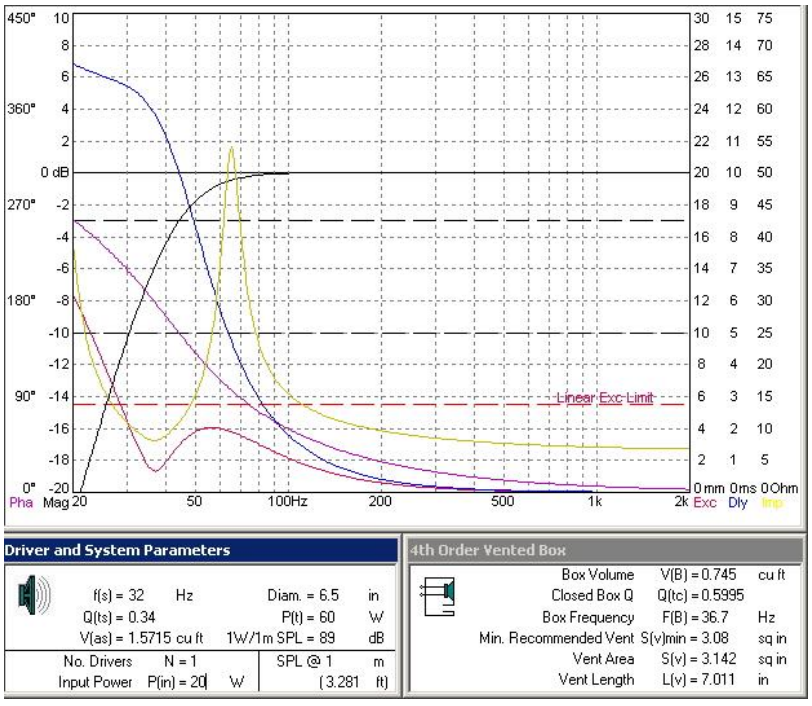
Sensitivity: 89 dB

Price: $48.00



This woofer was an early favorite that was barely beat by the Dayton Audio woofer in Winspeakerz modeling. It did well, but it was capable of 3 dB less output than the Dayton Audio woofer and slightly less bass extension due to its smaller size and limited power handling.





Woofer #3 Detail – Scanspeak Discovery 18W/4434G-00

Frequency Range: 50 – 5000 Hz

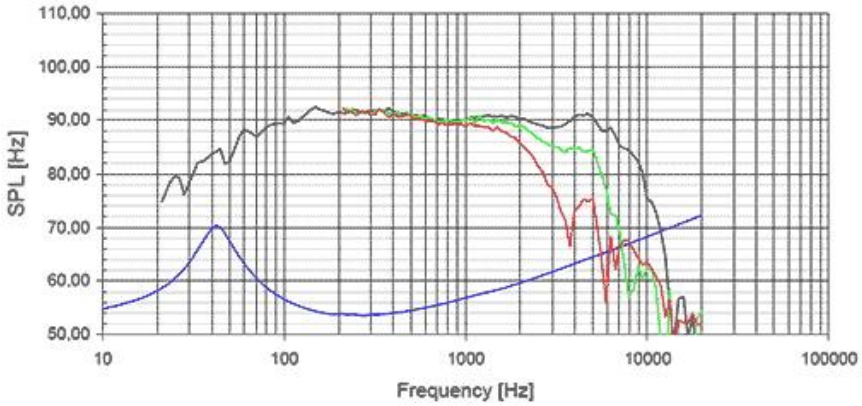
Power Handling: 120 W

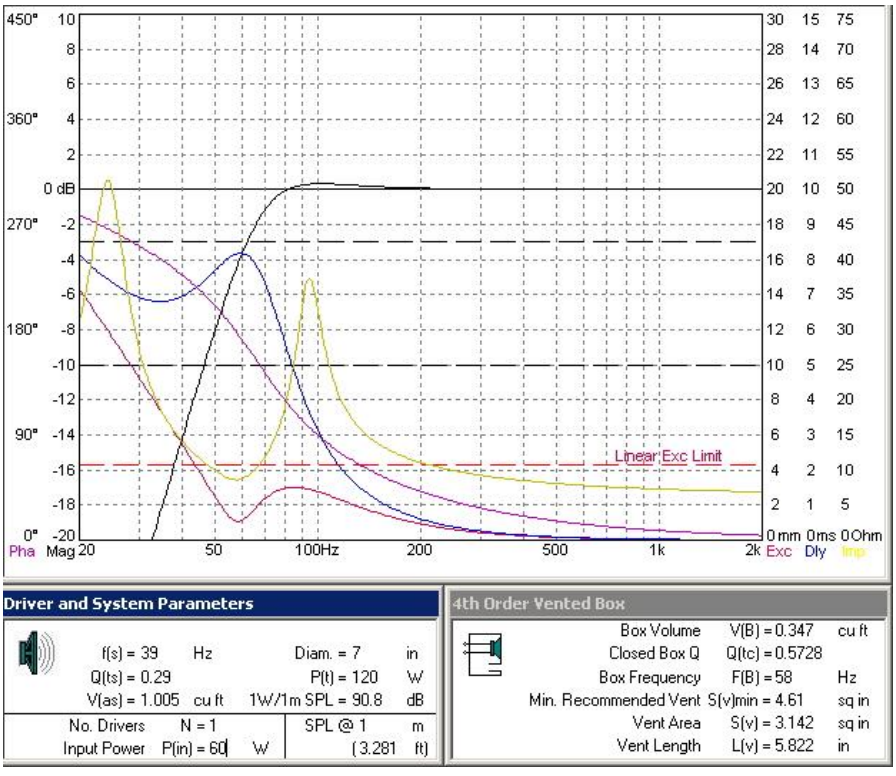
Diameter: 7 in.

Sensitivity: 90.8 dB

Price: $73.75

This 7 inch woofer was my third choice, passed over largely because it was more expensive but did not produce as low a bass extension as the Dayton Audio Reference woofer.





Woofer #4 Detail – Seas Prestige U18RNX/P

Frequency Range: 55 – 4000 Hz

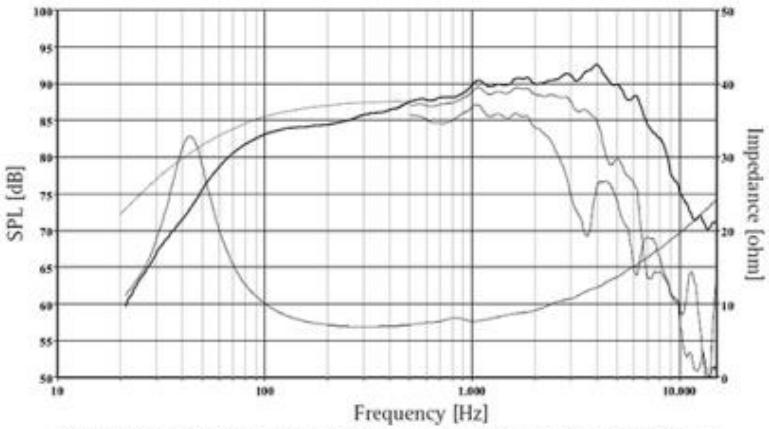
Power Handling: 80 W

Diameter: 7 in.

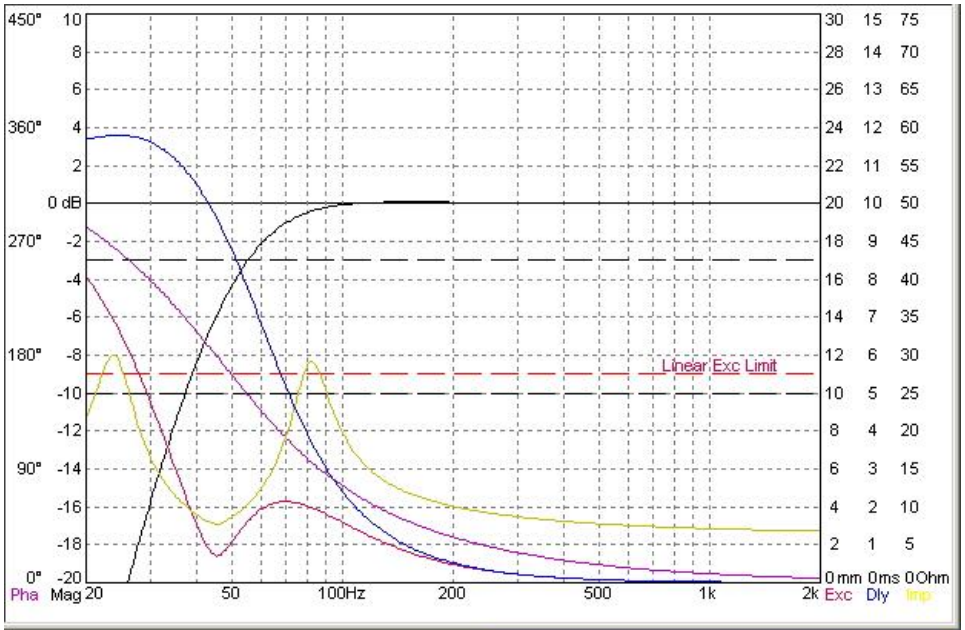
Sensitivity: 88 dB

Price: $101.10

This 7” woofer did well for its size, but is nearly twice the price of the Dayton Audio Reference woofer without any clear advantages to me.



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.



Driver and System Parameters

f(s) = 43	Hz		Diam. = 7	in
Q(ts) = 0.37			P(t) = 80	W
V(as) = 0.777	cu ft	1W/1m	SPL = 88	dB
No. Drivers	N = 1		SPL @ 1	m
Input Power	P(in) = 80	W	(3.281	ft)

4th Order Vented Box

Box Volume	V(B) = 0.436	cu ft	
Closed Box Q	Q(tc) = 0.6179		
Box Frequency	F(B) = 45.2	Hz	
Min. Recommended Vent	S(v)min = 9.19	sq in	
Vent Area	S(v) = 7.069	sq in	
Vent Length	L(v) = 19.28	in	

Woofer #5 Detail – Dayton Audio DS215-8 Designer Series

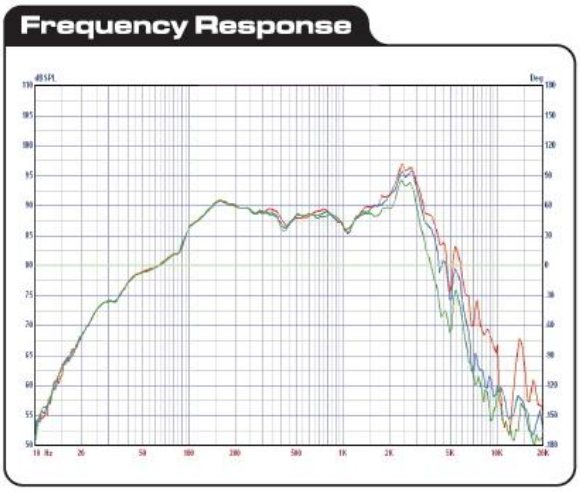
Frequency Range: 50 – 2000 Hz

Power Handling: 80 W

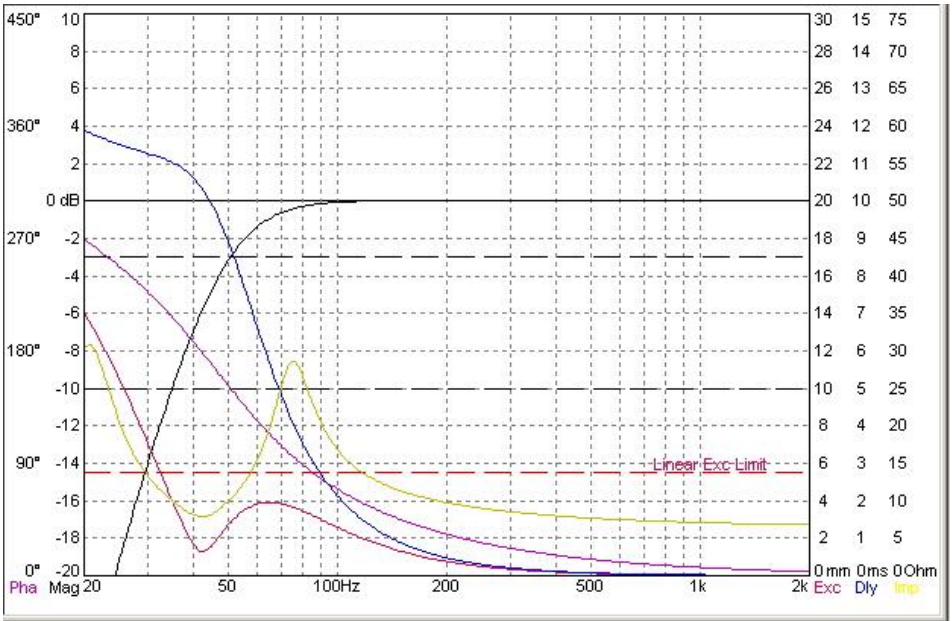
Diameter: 8 in.

Sensitivity: 90.1 dB

Price: $43.20



This is a woofer I found on the way to the Dayton Reference that I intend to buy. Its frequency response is not very good, but I gave it a try in Winspeakerz modeling. Besides its price, it did not have any advantages over any of the woofers with flatter frequency responses.



Driver and System Parameters

f(s) = 36.7	Hz		Diam. = 8	in	
Q(ts) = 0.34			P(t) = 80	W	
V(as) = 1.384	cu ft		1W/1m SPL = 90.1	dB	
No. Drivers	N = 1		SPL @ 1	m	
Input Power	P(in) = 80	W	(3.281	ft)	

4th Order Vented Box

Box Volume	V(B) = 0.656	cu ft
Closed Box Q	Q(tc) = 0.5993	
Box Frequency	F(B) = 42.2	Hz
Min. Recommended Vent	S(v)min = 6.02	sq in
Vent Area	S(v) = 3.142	sq in
Vent Length	L(v) = 5.816	in

Tweeter Analysis and Selection

	CAT 298[14]	**RS28F-4[15]**	MDT 12[16]	CAT 408[17]	DC28F-8[18]
Frequency Range (Hz)	1500 – 20k	**1200 – 20k**	1800 – 25k	1500 – 20k	1300 – 20k
Power Handling (W)	80	**100**	80	120	50
Diameter (inches)	1 1/8	**1 1/8**	1 1/8	1 1/8	1 1/8
Sensitivity (dB)	89	**88**	89	89	89
f(s) (Hz)	900	**530.9**	1000	780	637.2
Price ($)	52.70	**54.75**	34.90	78.80	19.75

Tweeter #1 Detail – Dayton Audio RS28F-4

Frequency Range: 1200 – 20,000 Hz

Power Handling: 100 W

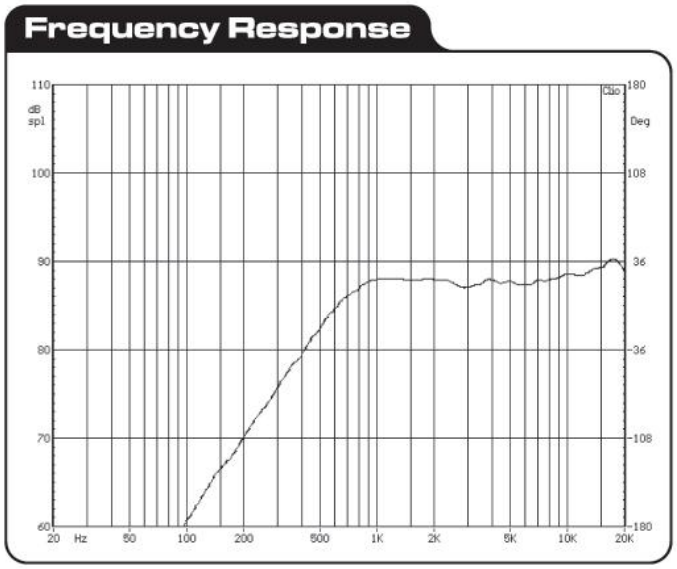
Dome Diameter: 1 1/8 in.

Sensitivity: 88 dB

f(s): 530.9 Hz

Price: $54.75

The Dayton Audio RS28F-4 silk dome tweeter is my first choice and the tweeter I plan to purchase. I especially like its relatively flat frequency response that will work very well with my chosen woofer. Upon further inspection, I discovered that this tweeter is actually made to work well with woofers in the Dayton Audio Reference series. It reaches



[14] Morel. "CAT 298 Classic Advanced Tweeter." *Parts Express.*
[15] Dayton Audio. "RS28F-4 1-1/8" Silk Dome Tweeter." *Parts Express.*
[16] Morel. "MDT 12 - Soft Dome Tweeter." *Parts Express.*
[17] Morel. "CAT 408 Classic Advanced Tweeter." *Parts Express.*
[18] Dayton Audio. "DC28F-8 1-1/8" Silk Dome Tweeter." *Parts Express.*

very low for its size with a very low f(s); low enough for me to have a relatively low crossover and thus more ideal vertical dispersion. It also has a built-in grill that will help keep it from being damaged when it is transported.

Tweeter #2 Detail – Morel CAT 298

Frequency Range: 1500 – 20,000 Hz

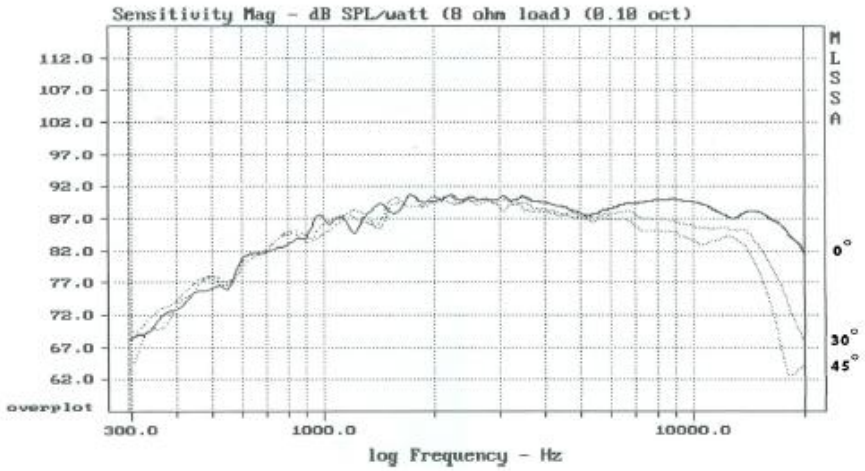
Power Handling: 80 W

Dome Diameter: 1 1/8 in.

Sensitivity: 89 dB

f(s): 900 Hz

Price:



This tweeter was my second choice. It was very similar to the Dayton Audio RS28F-4, but its response is not as flat between 1000 Hz and 2000 Hz, where I want to put my crossover. The f(s) of this tweeter being 900 Hz is also problematic for a low crossover.

Tweeter #3 Detail – Morel MDT 12

Frequency Range: 1800 – 25,000 Hz

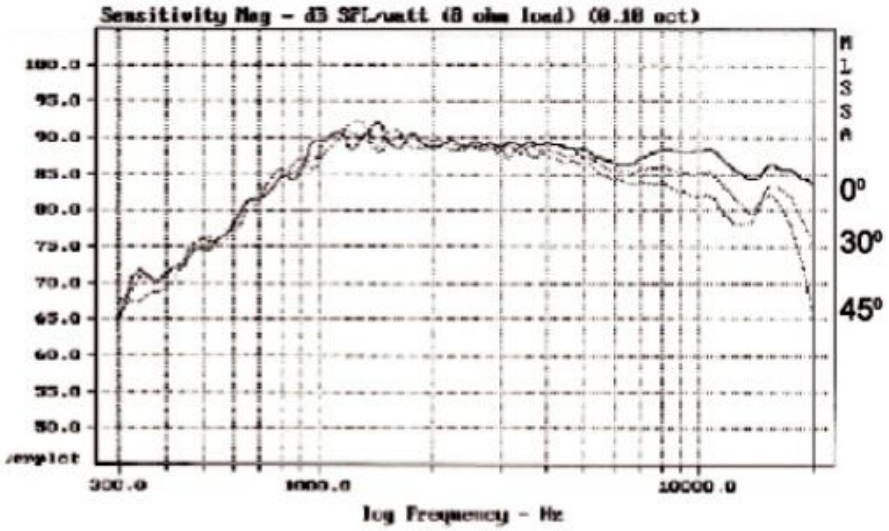
Power Handling: 80 W

Dome Diameter: 1 1/8 in.

Sensitivity: 89 dB

f(s): 1000 Hz

Price: $34.90



This tweeter was my third choice. It was a good price, but its recommended frequency range did not reach as low as I'd hoped for my ideal crossover, and its f(s) is much too high for my design.

Tweeter #4 Detail – Morel CAT 408

Frequency Range: 1500 – 20,000 Hz

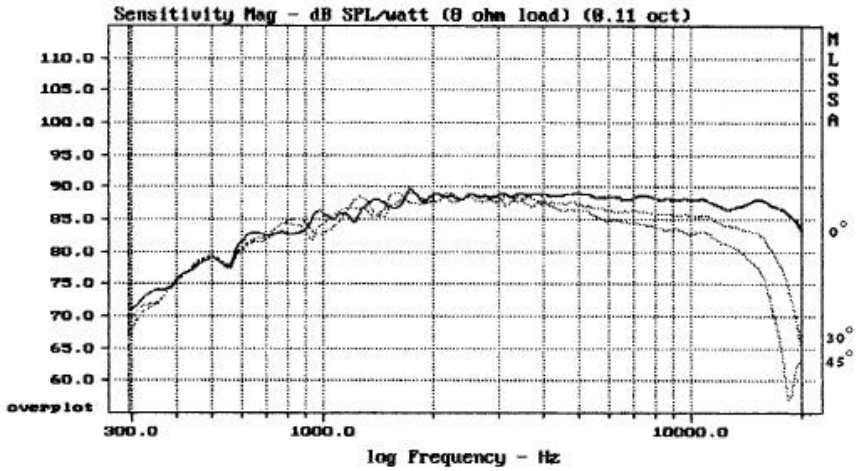
Power Handling: 120

Dome Diameter: 1 1/8 in.

Sensitivity: 89 dB

f(s): 780 Hz

Price: $78.80



This is another good tweeter, but it is rather expensive and, like the MDT 12, does not have the flattest response between 1000 – 2000 Hz (nor is it recommended for use

below 1500 Hz). This tweeter is compact and has impressive power handling capabilities, but neither of those attributes is necessary to me, especially for the extra price.

Tweeter #5 Detail – Dayton Audio DC28F-8

Frequency Range: 1300 – 20,000 Hz

Power Handling: 50 W

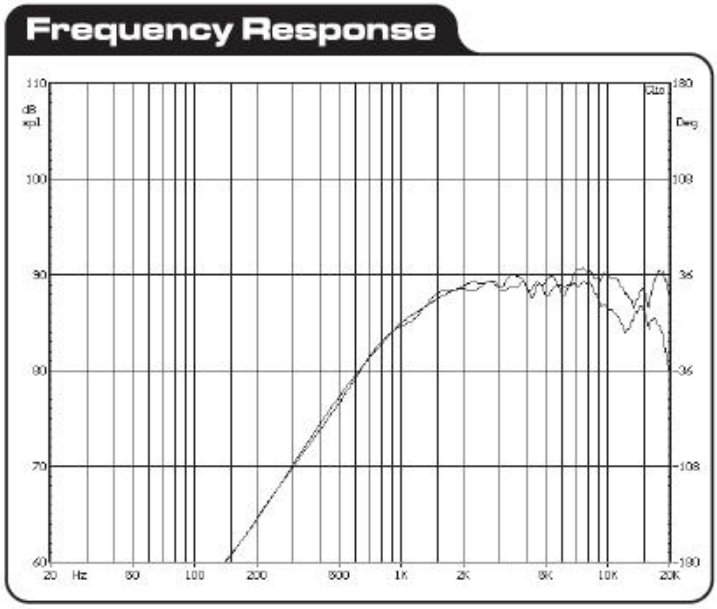
Dome Diameter: 1 1/8 in.

Sensitivity: 89 dB

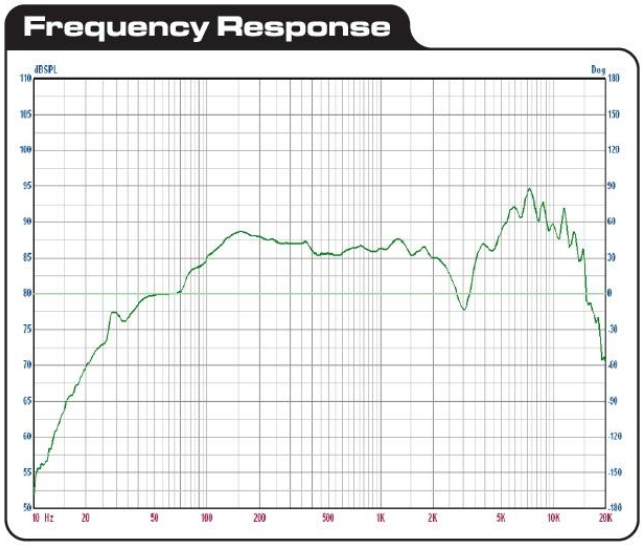
f(s): 637.2 Hz

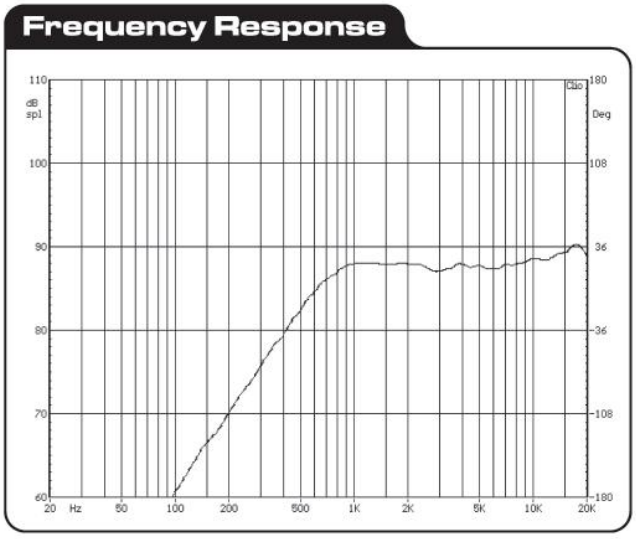
Price: $19.75

This tweeter was a great price, but was passed over because of its low power handling capabilities and a frequency response that was less than ideal.



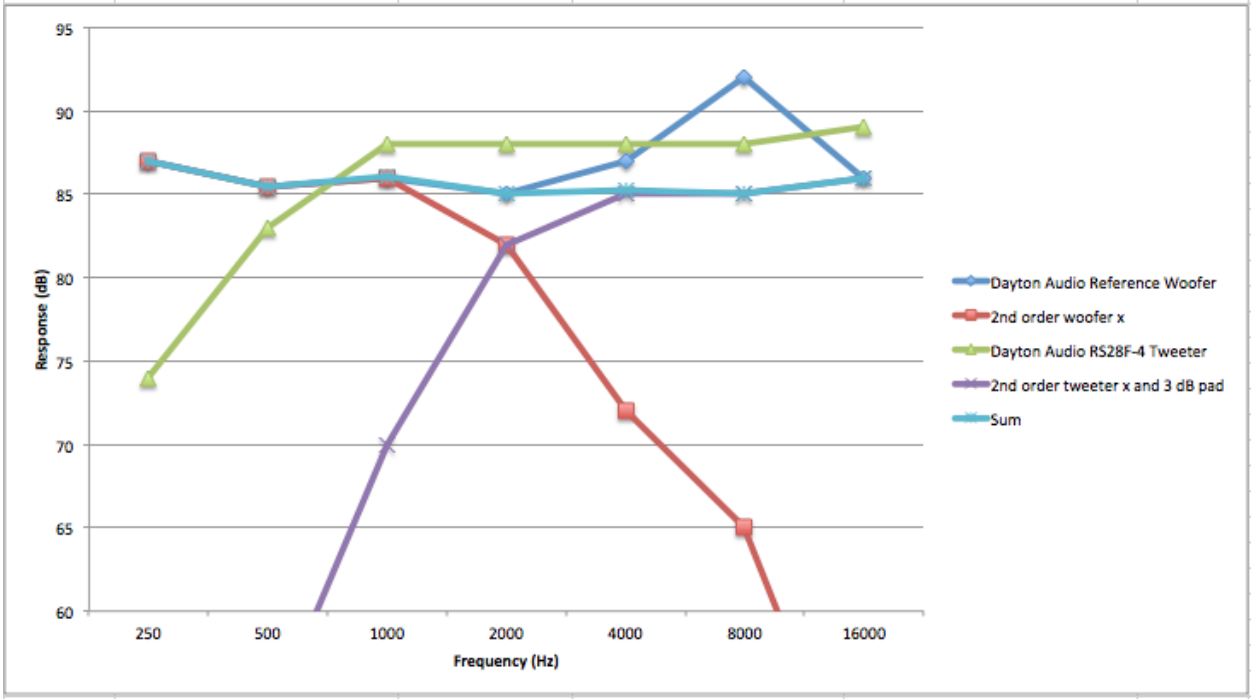
Crossover Design



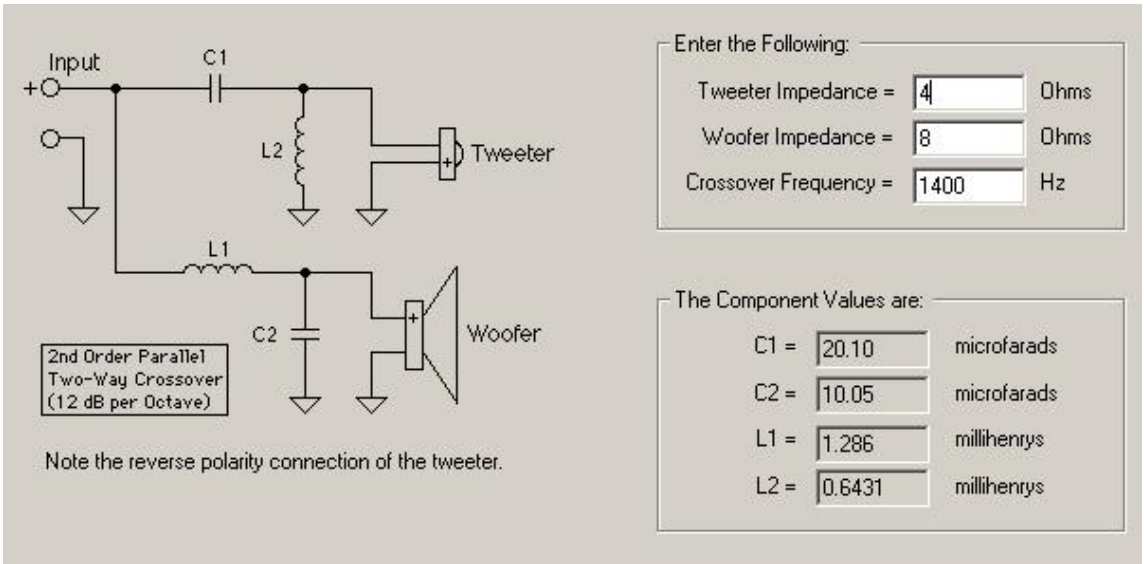


My crossover is designed to produce the flattest possible response, one that does not affect voicing. The following Excel mockup shows that 2nd order rolloffs on both the woofer and the tweeter with a -3 dB pad on the tweeter should result in a very flat response. The figure shows a reasonable crossover point of 2000 Hz, but it works just as well anywhere between 2000 and 1000 Hz. I will get the crossover as low in frequency as I can without overworking the tweeter.

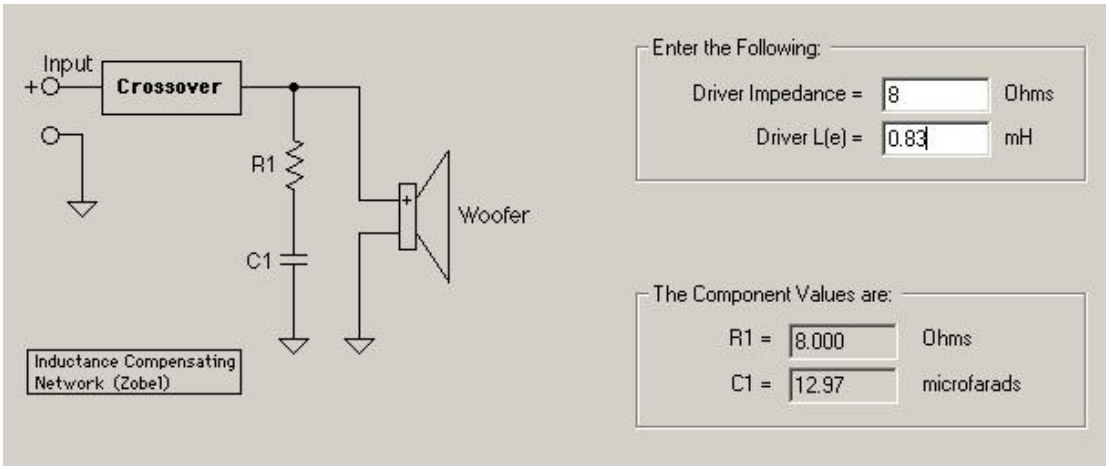
	Dayton Audio Reference Woofer	2nd order woofer x	Dayton Audio RS28F-4 Tweeter	2nd order tweeter x and 3 dB pad	Sum
250	87	87	74	32	87.0000137
500	85.5	85.5	83	53	85.5024415
1000	86	86	88	70	86.1077423
2000	85	82	88	82	85.0103
4000	87	72	88	85	85.212384
8000	92	65	88	85	85.0432137
16000	86	47	89	86	86.0005467



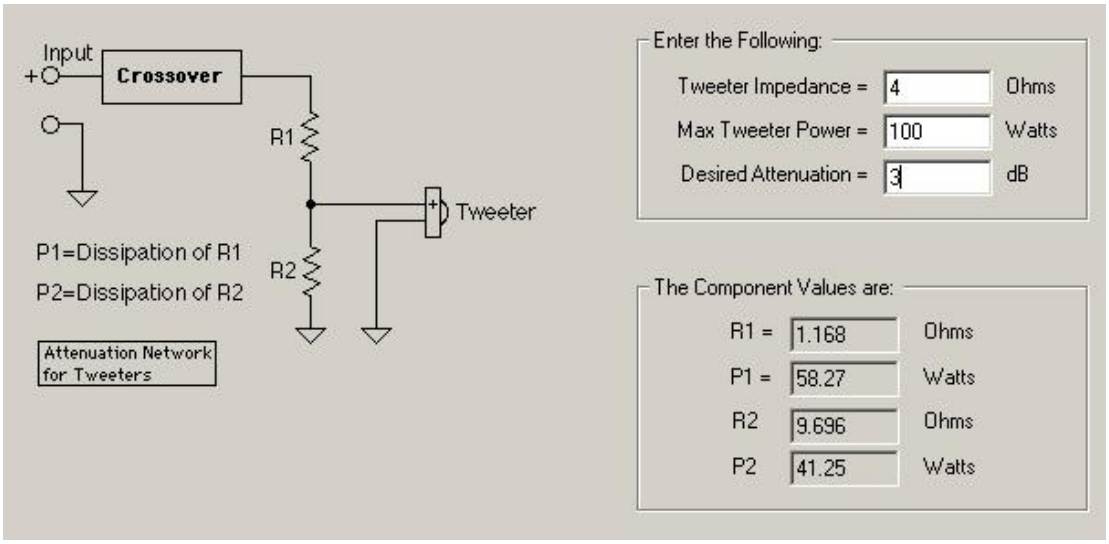
Using Winspeakerz, I determined which components I would need for a 2nd order Butterworth crossover at 1400 Hz. This may be the lowest I can go without a high risk of tweeter damage.



I also used Winspeakerz to determine the impedance flattening circuit for my woofer,



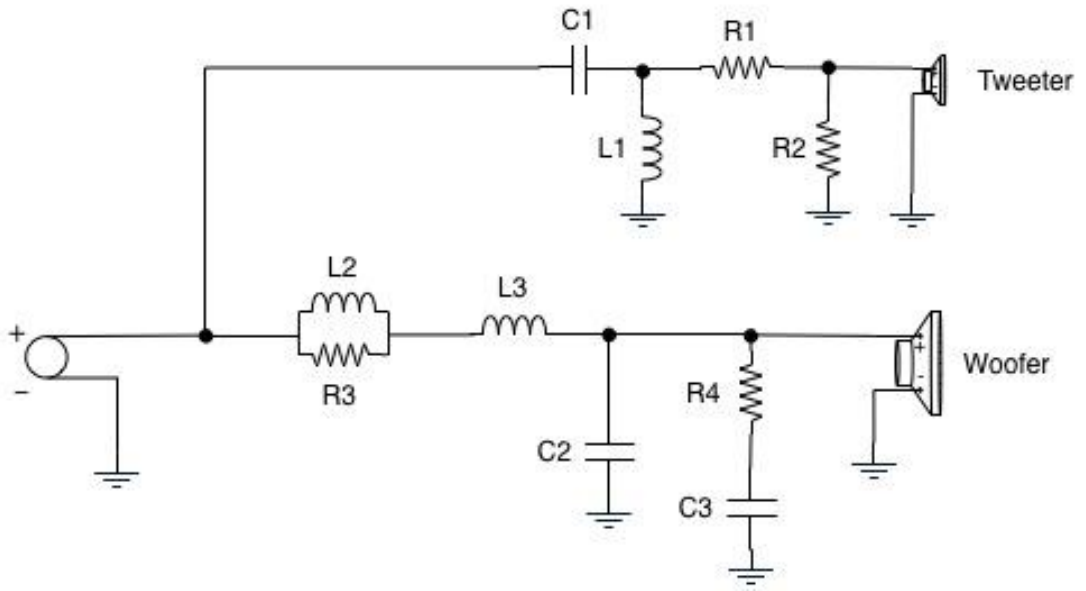
and to determine a tweeter attenuation circuit to pad the tweeter by 3 dB.



I will also include a baffle step correction circuit to pad frequencies above 456 Hz.[19]

Below is the complete crossover design with calculations for a crossover at 1400 Hz. I will also test a crossover near 2000 Hz and listen for potential benefits and detriments.

[19] King, Martin J. "Simple Sizing of the Components in a Baffle Step Correction Circuit."



C1 = 20.10 microfarads
C2 = 10.05 microfarads
C3 = 12.97 microfarads

R1 = 1.168 ohms
R2 = 9.696 ohms
R3 = 3.300 ohms
R4 = 8.000 ohms

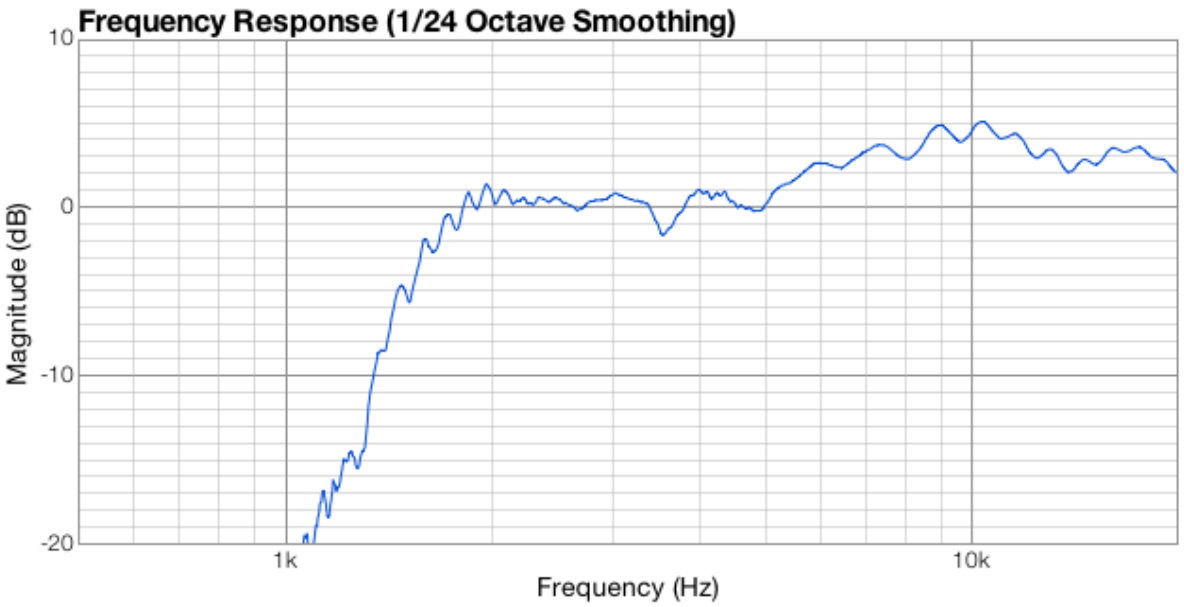
L1 = 0.6431 millihenrys
L2 = 1.1518 millihenrys
L3 = 1.2860 millihenrys

Production/Project: Baby Blues		
Location: Michigan Technological University		
Designer: Lindsey Johns		FA 4740
Drafter: Lindsey Johns	Date Drawn: 3/8/13	Revision #: 1
Production Date: 2013	Scale: N/A	Drawing #: 1 of 1
Drawing Title: Crossover Design		

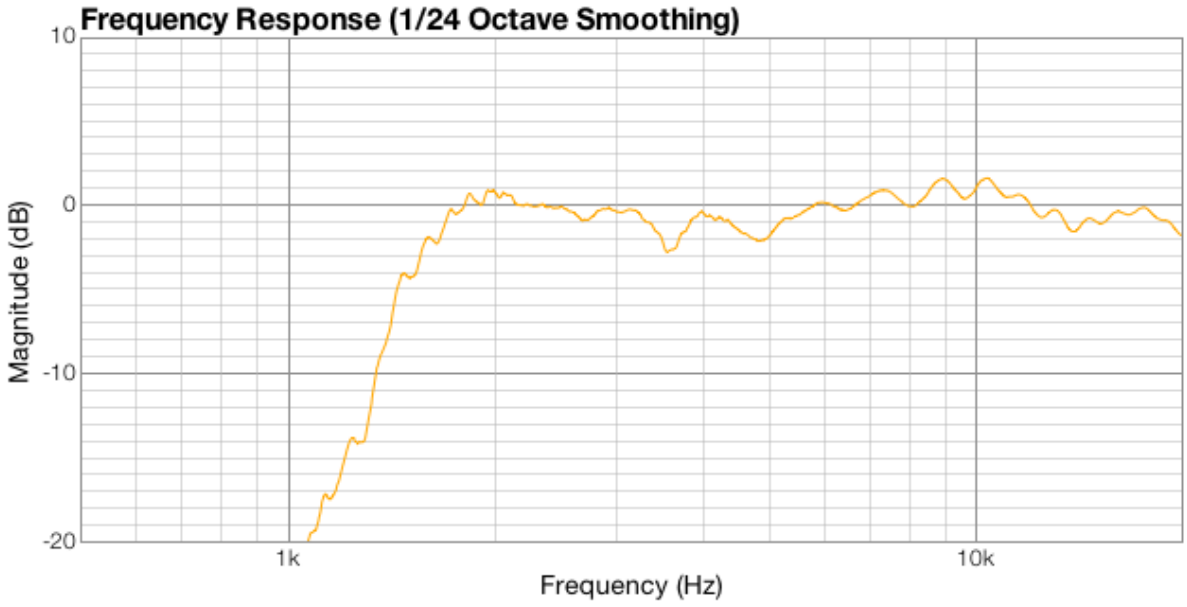
Testing and Tuning

Driver Performance

When installed in the cabinet, the tweeter exhibited a serious boost above 5 kHz:



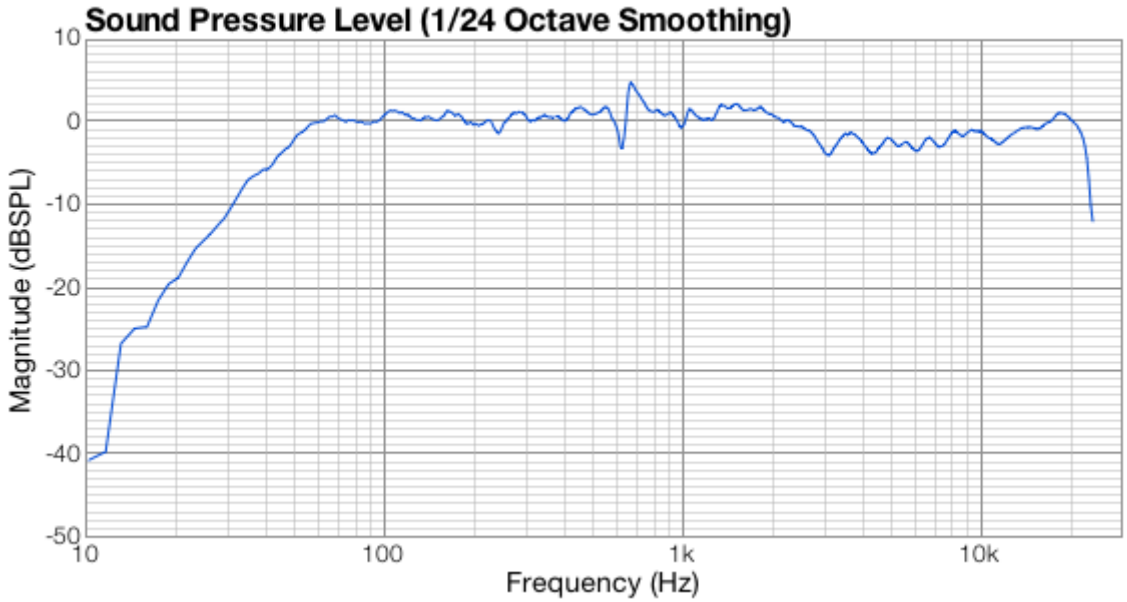
I compensated for this by adding a baffle step attenuation circuit at 5 kHz, resulting in an appropriate amount of flattening:



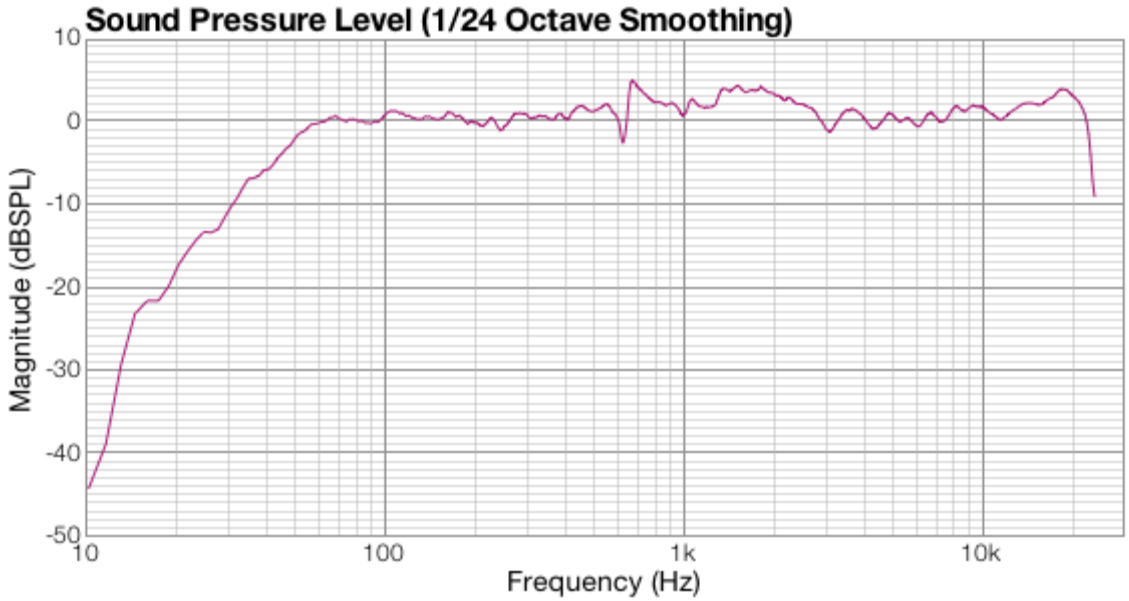
The woofer did not have any similar issues.

Cross-over Tuning

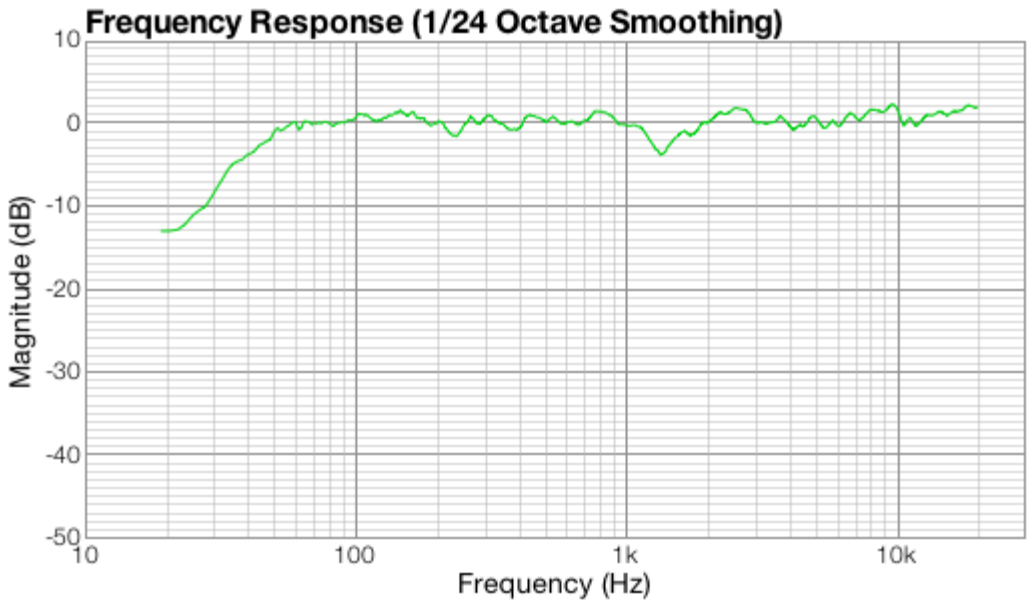
My first data made it clear that the 3 dB pad on the tweeter was not necessary.



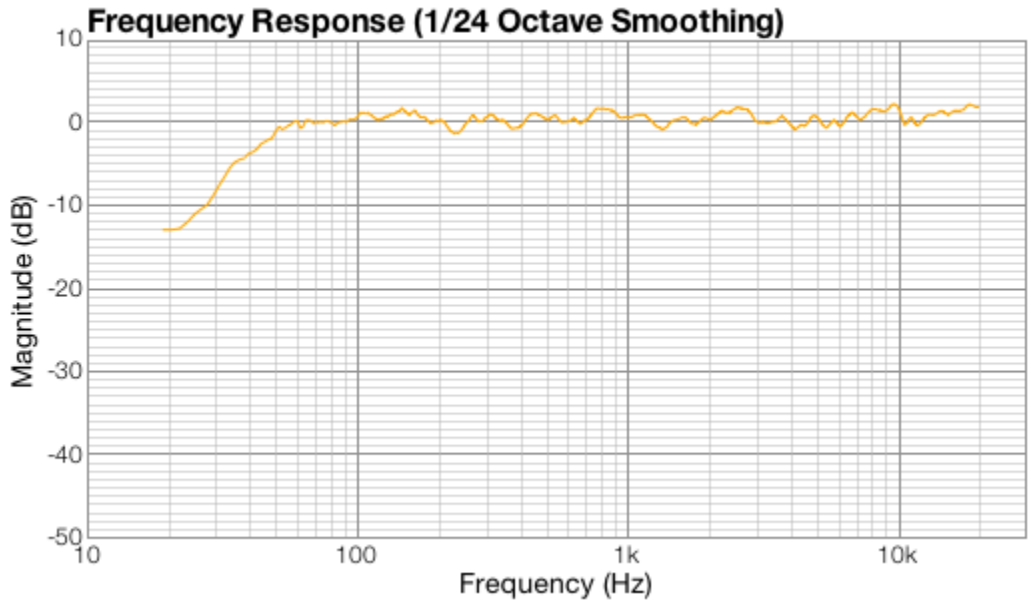
Removing the pad made most of the tweeter level with the woofer, but caused a boost at the crossover frequency.



It became apparent from individual driver testing that a third order crossover would be better suited to these drivers, so I tried one with the woofer at 1.6 kHz and the tweeter at 2 kHz.



That was too far, so I moved the woofer up to 2 kHz as well:



Enclosure Optimization

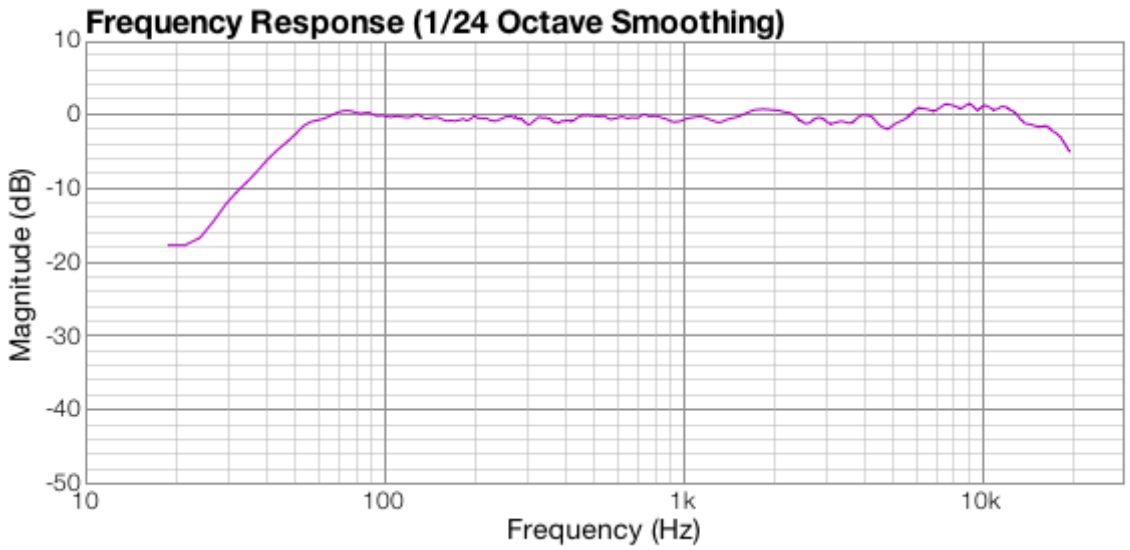
Despite the Sonic Barrier absorption on the back interior panel, the loudspeaker was producing a serious box resonance around 600 Hz. I accounted for this by adding fiberglass; I tried different amounts until I liked the way it sounded, then tested it again and the problem was gone. This can be seen in the above crossover tuning section; the first two figures are without fiberglass, and the second two are with.

Final System Documentation

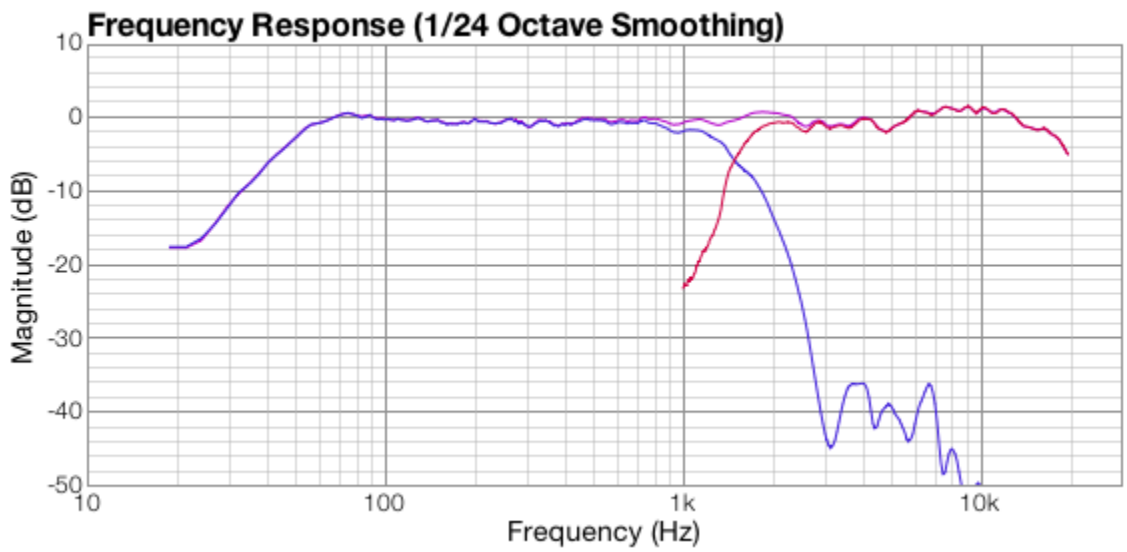
Final Testing Results

Overall Loudspeaker Performance

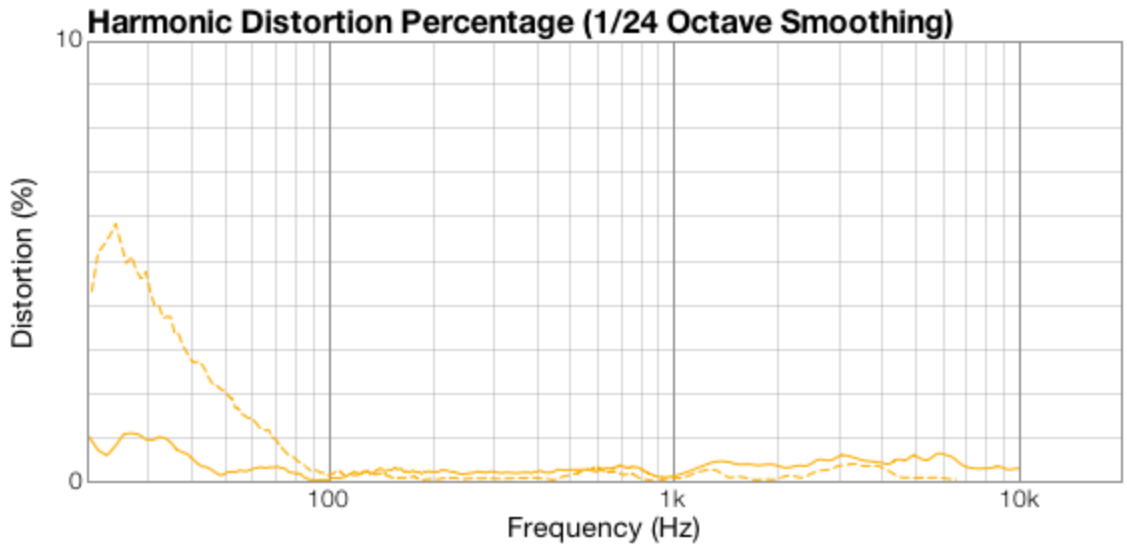
Frequency Response



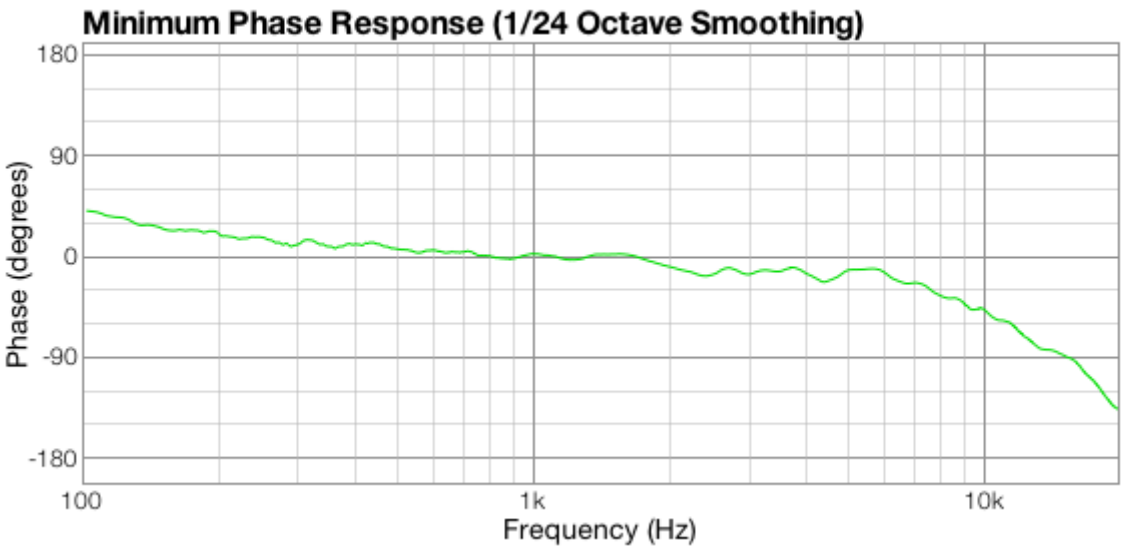
Integrated Frequency Response



Harmonic Distortion Percentage

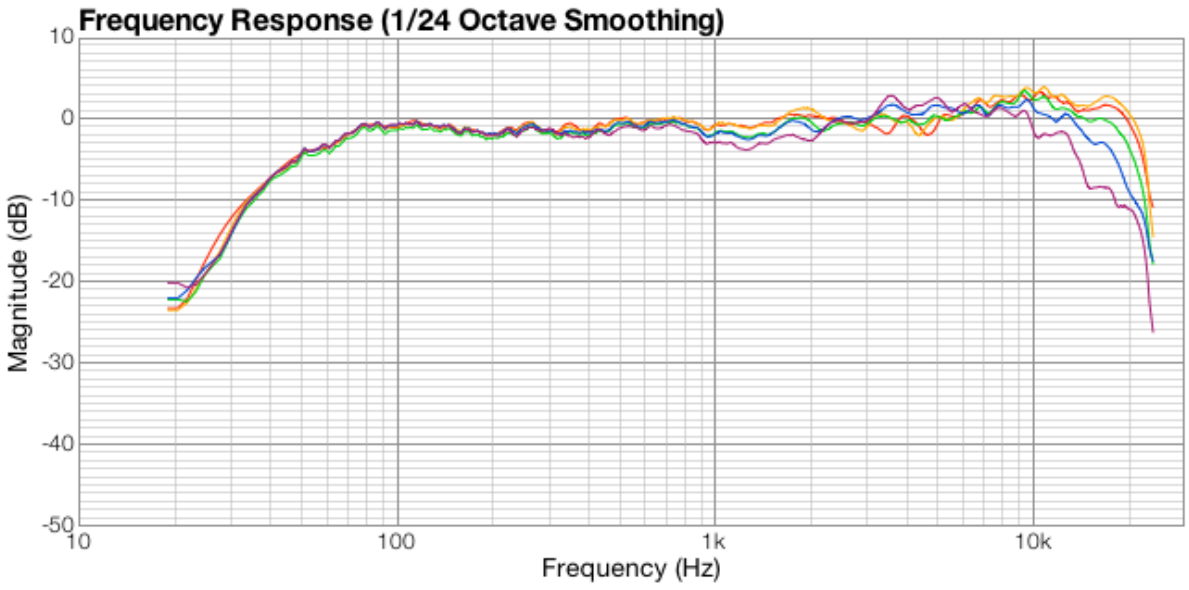


Minimum Phase

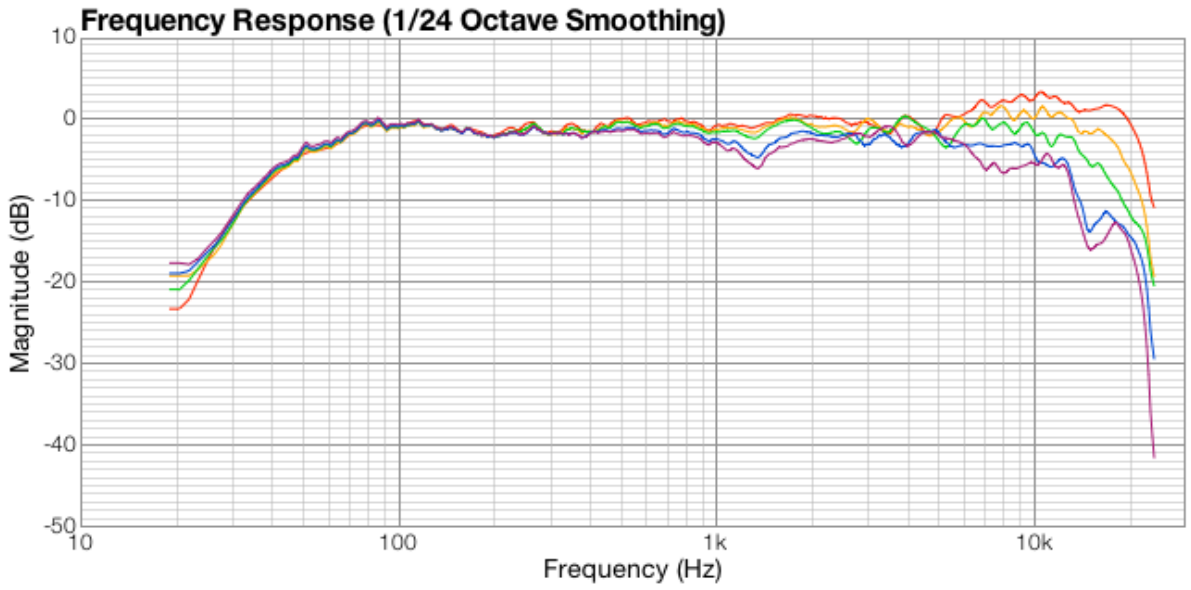


Horizontal Off-Axis Response

Left: (0°, 15°, 30°, 45°, 60°)

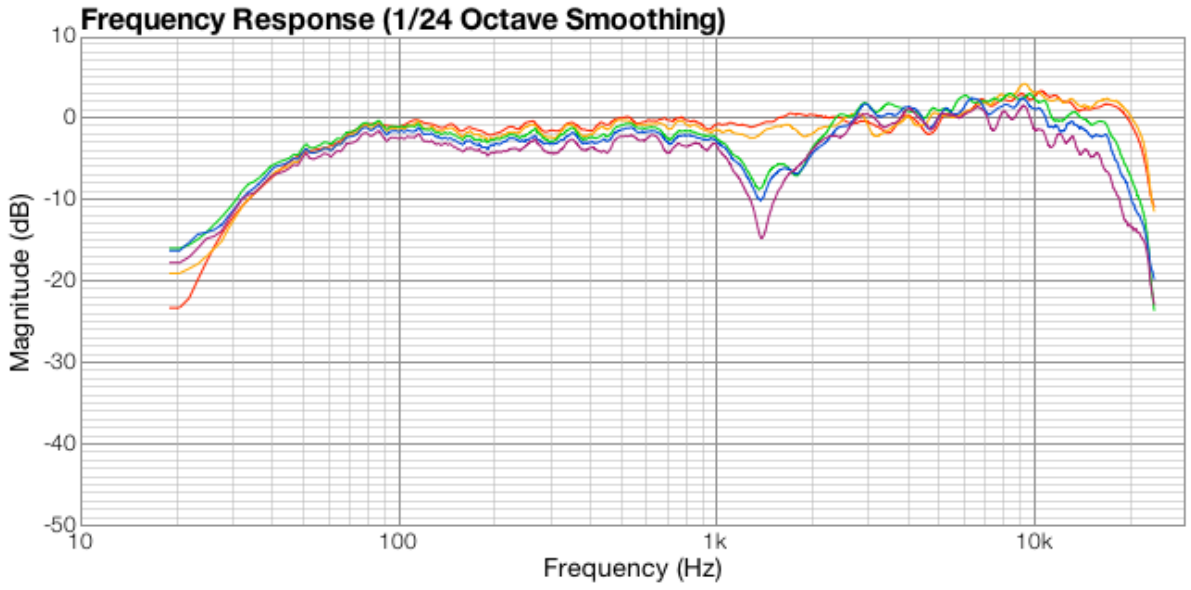


Right: (0°, 15°, 30°, 45°, 60°)

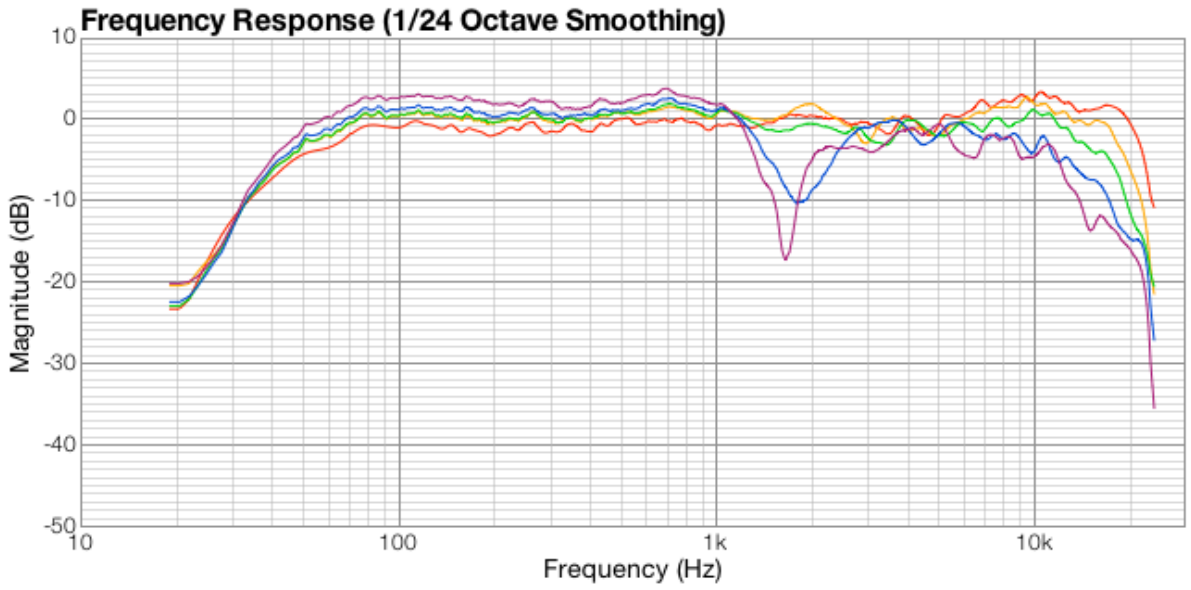


Vertical Off-Axis Response

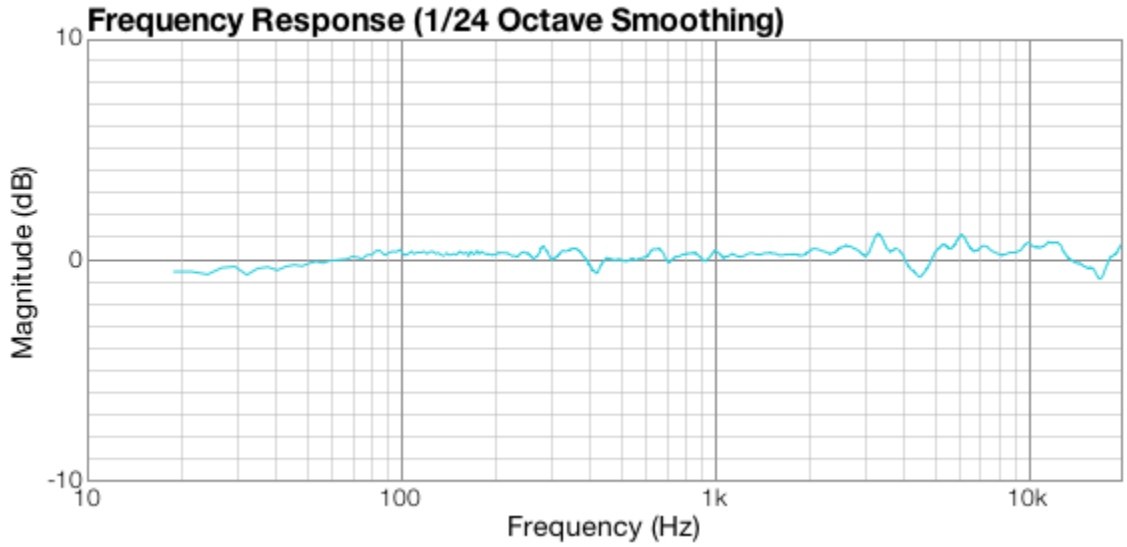
Up: (0°, 15°, 30°, 45°, 60°)



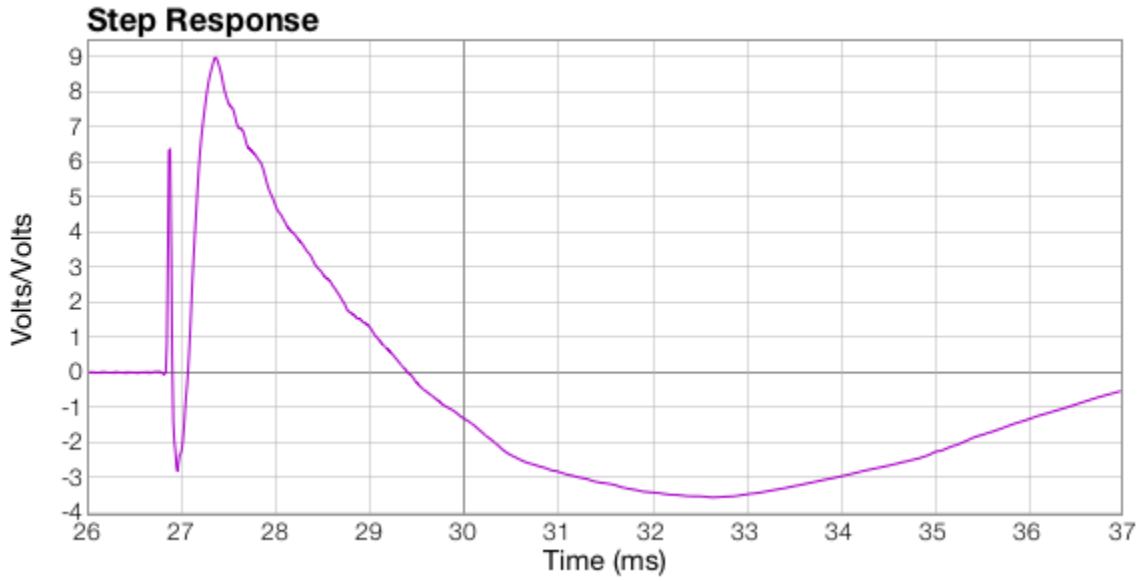
Down: (0°, 15°, 30°, 45°, 60°)



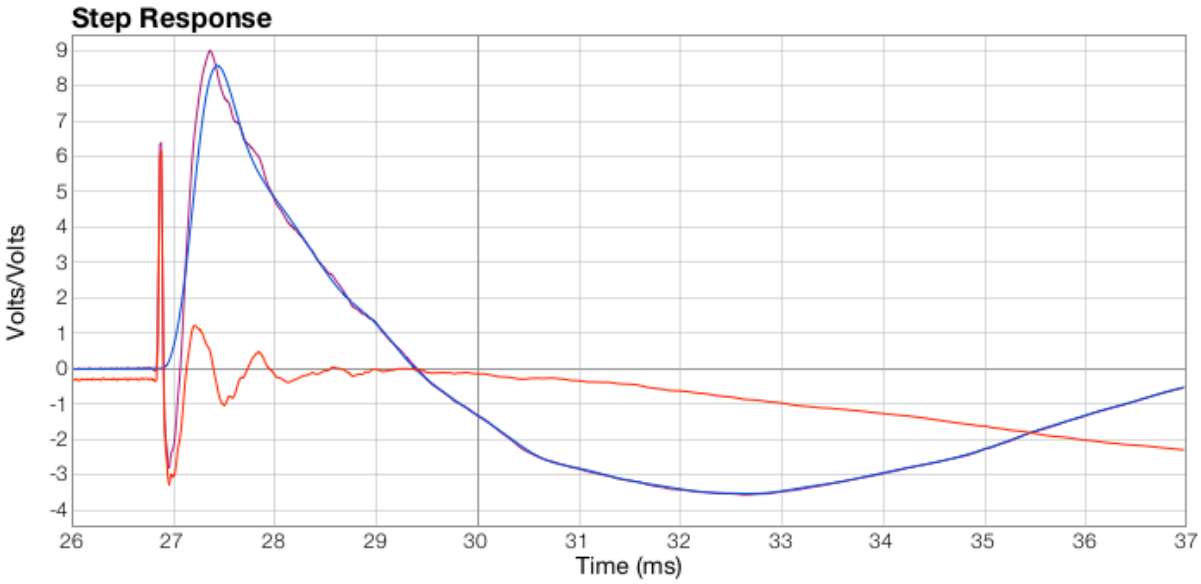
Difference Plot



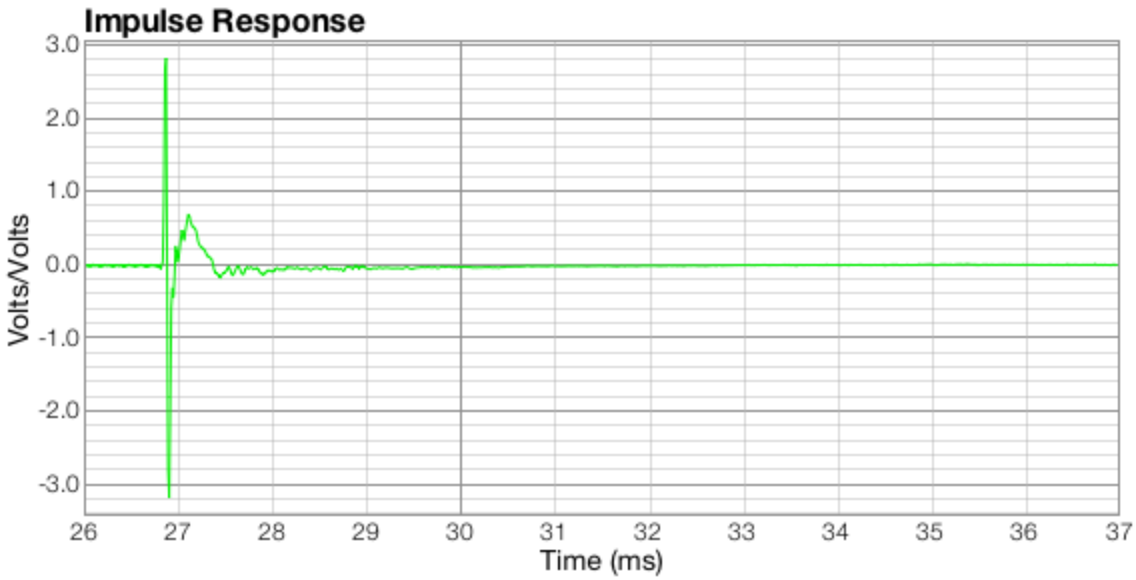
Step Response



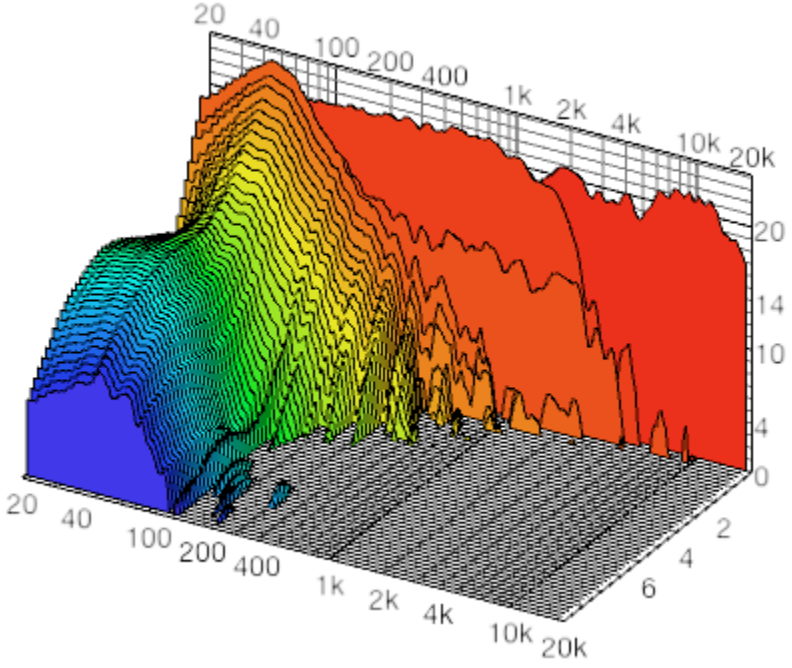
Integrated Step Response



Impulse Response

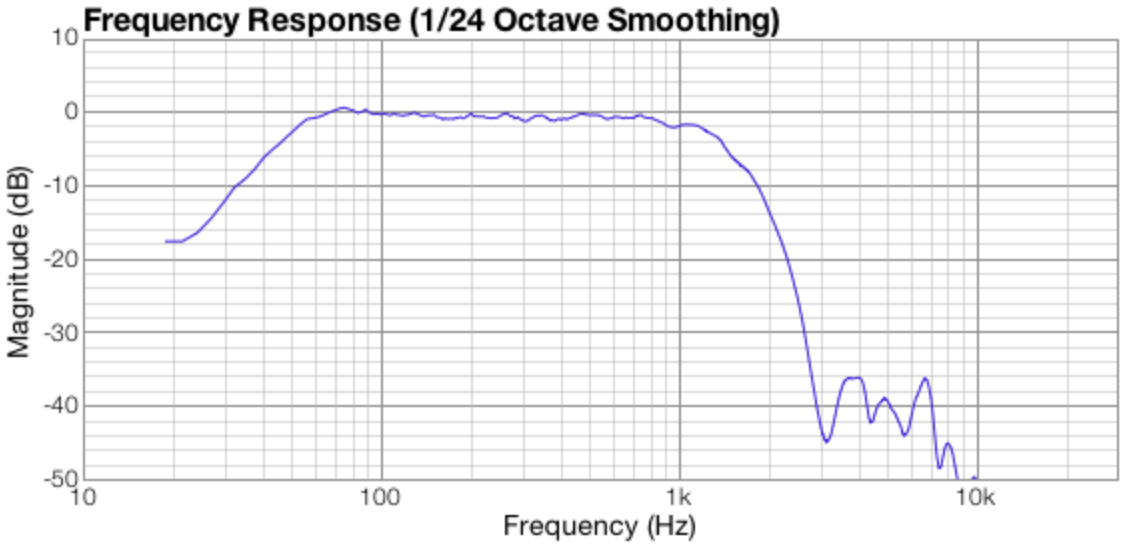


Waterfall Plot

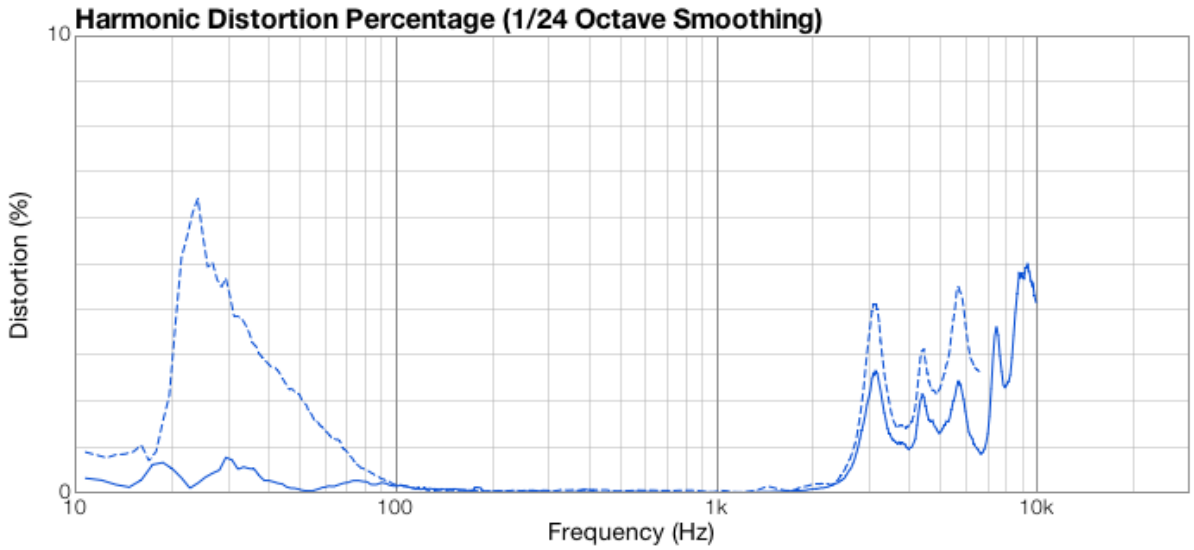


Woofer Performance

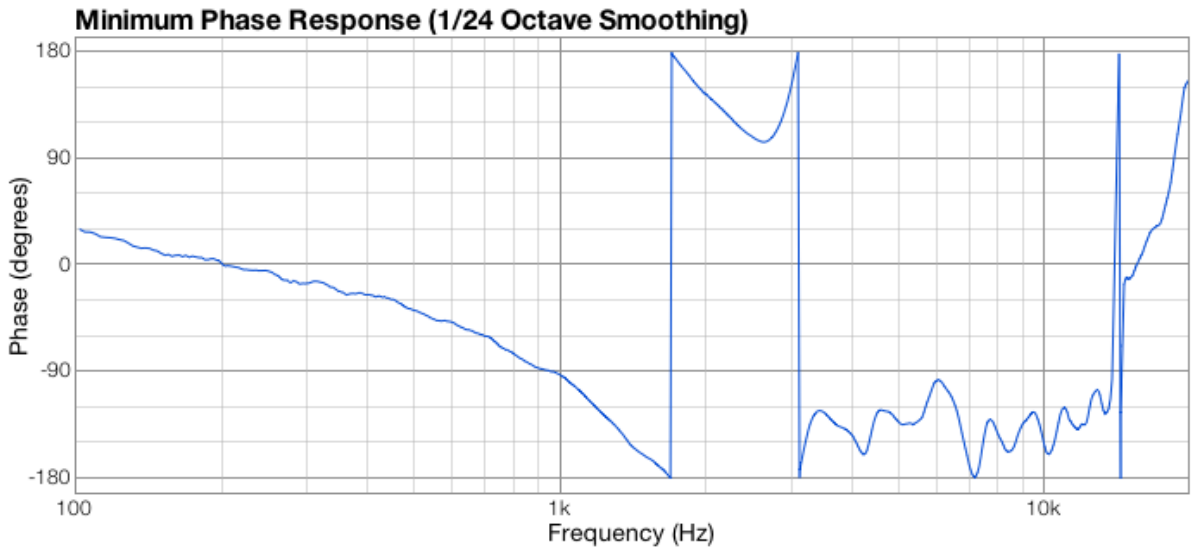
Frequency Response



Harmonic Distortion Percentage

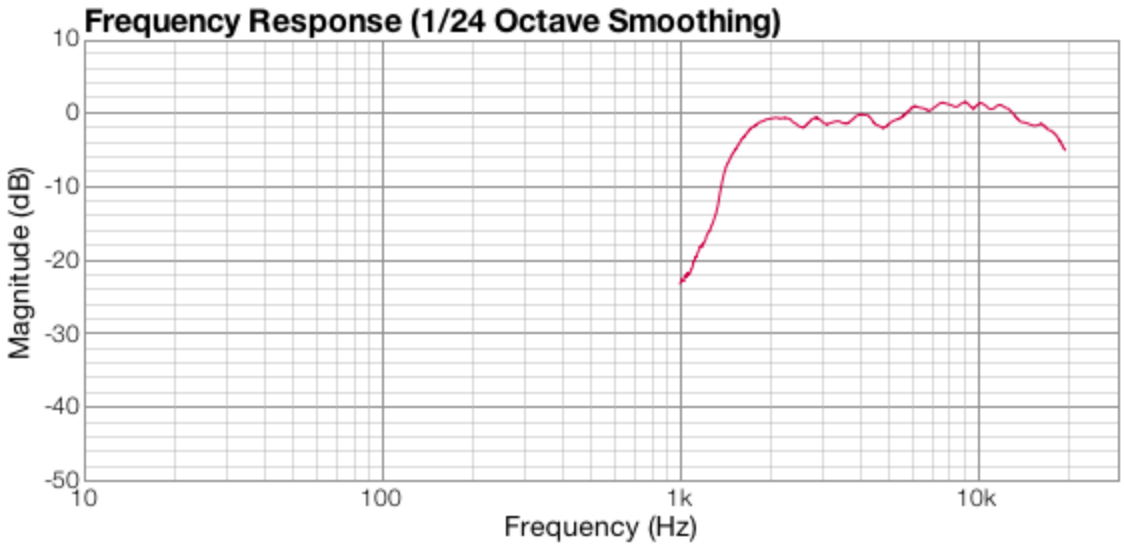


Minimum Phase

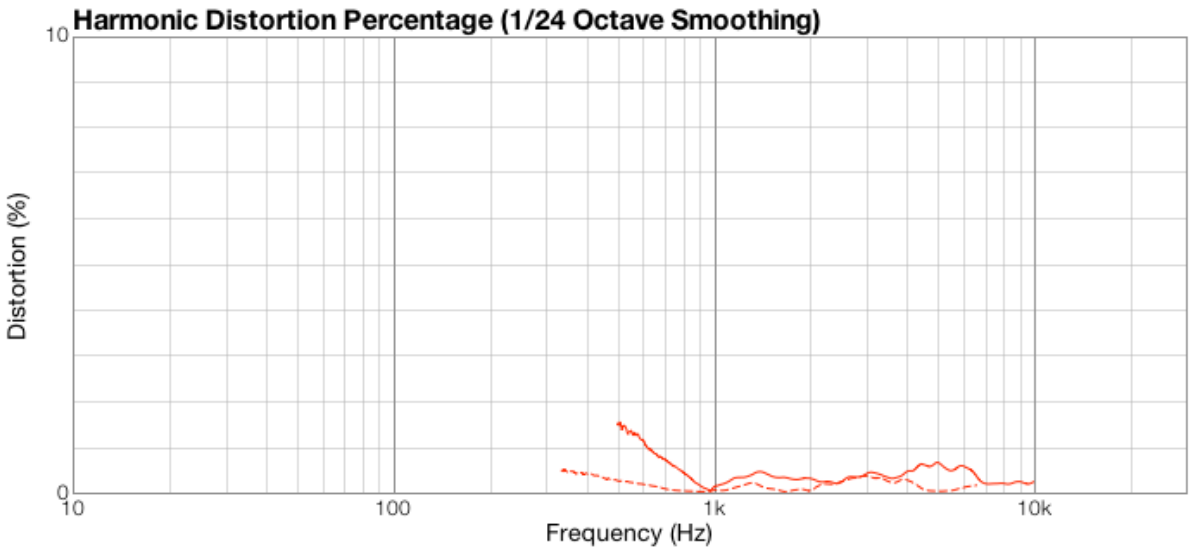


Tweeter Performance

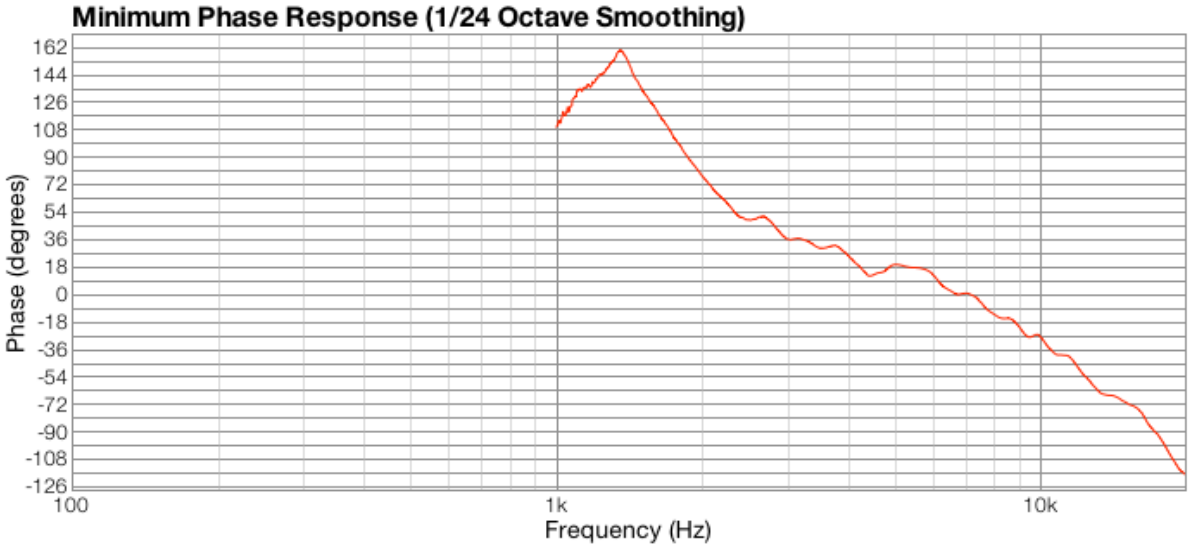
Frequency Response



Harmonic Distortion Percentage

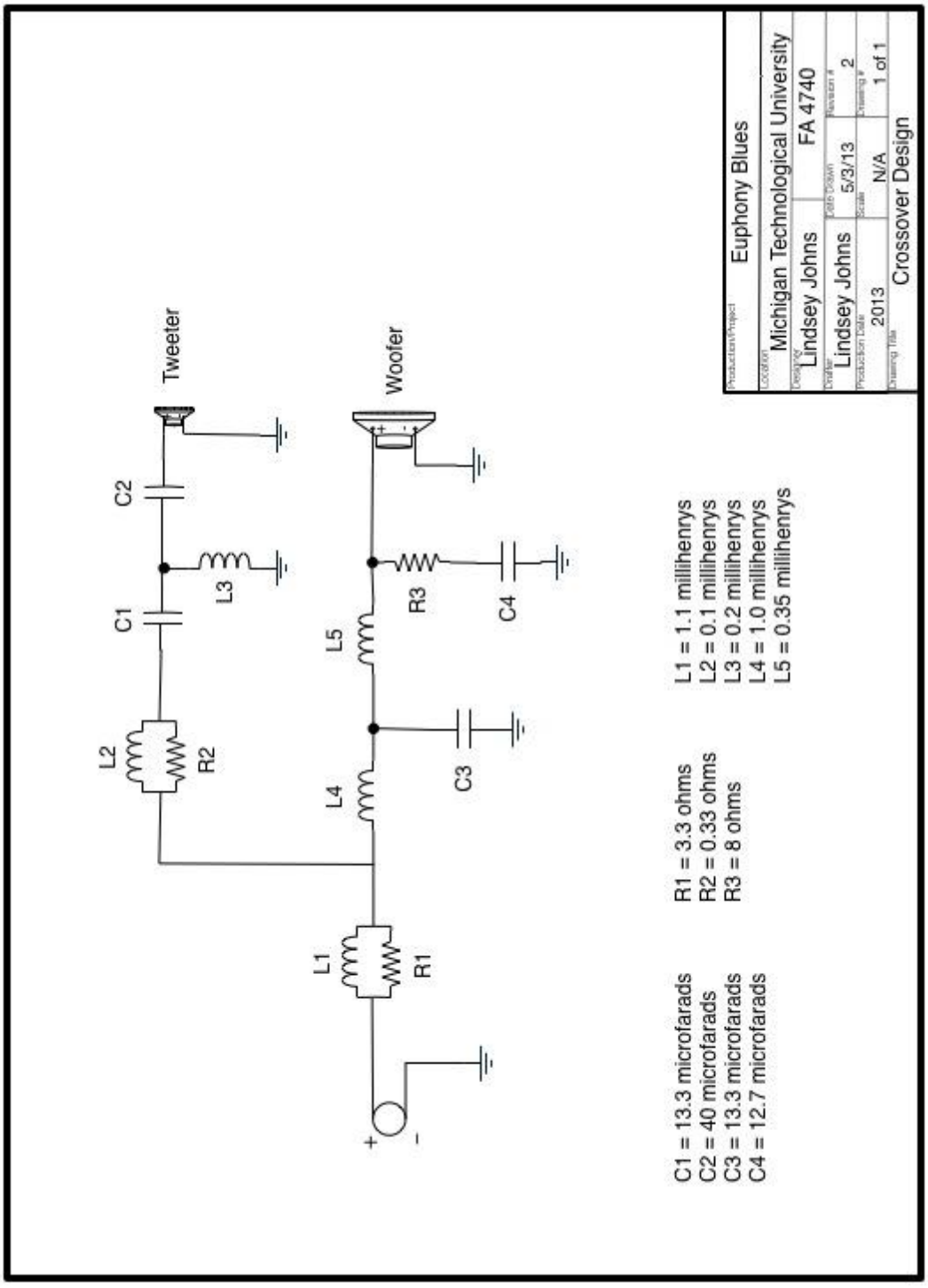


Minimum Phase

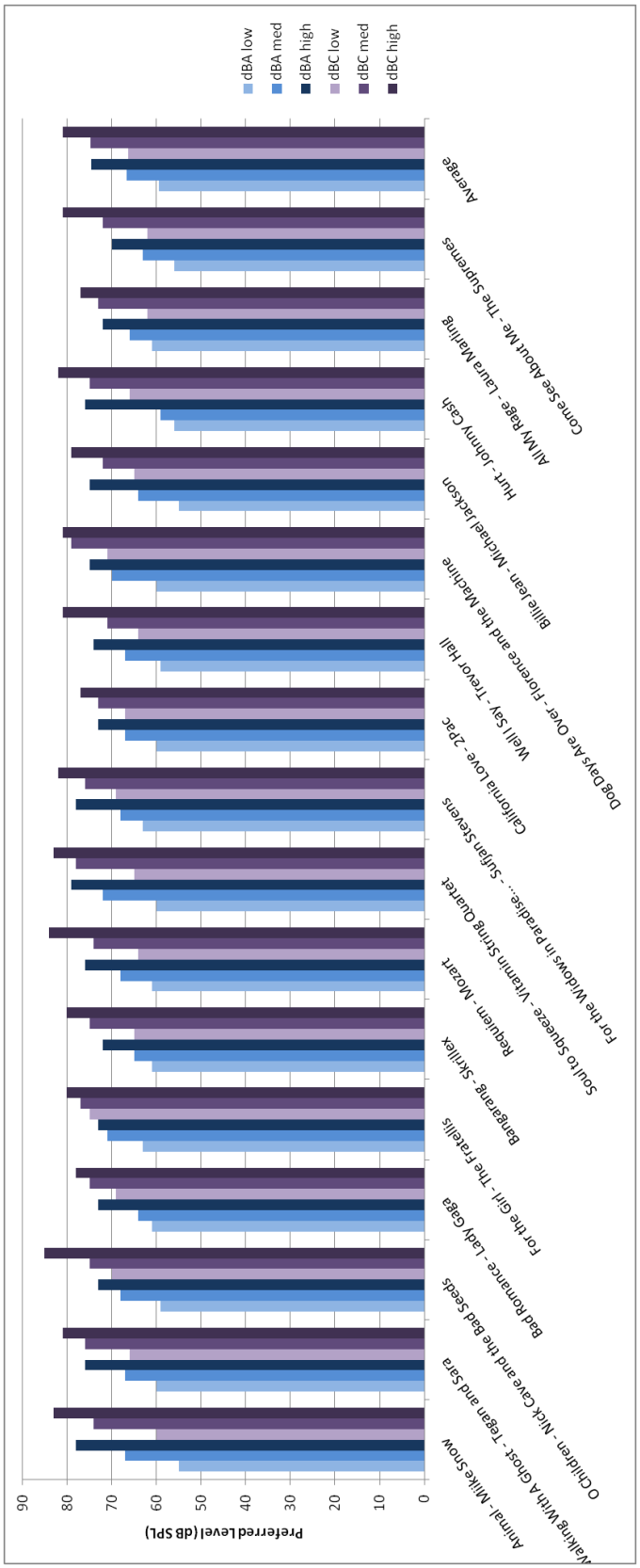


Cross-over Schematic (After Tuning)

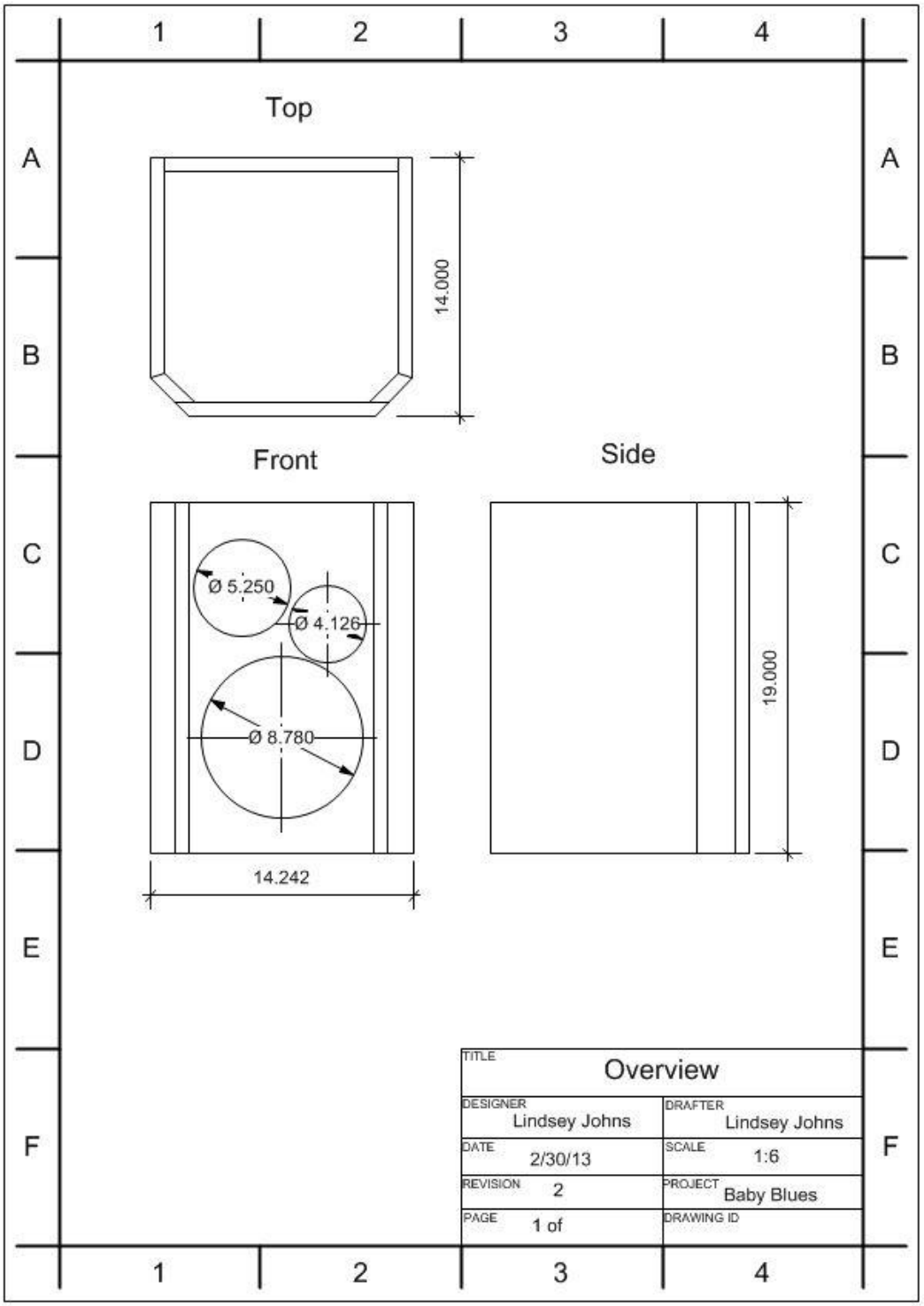
3rd order Butterworth at 2000 Hz.

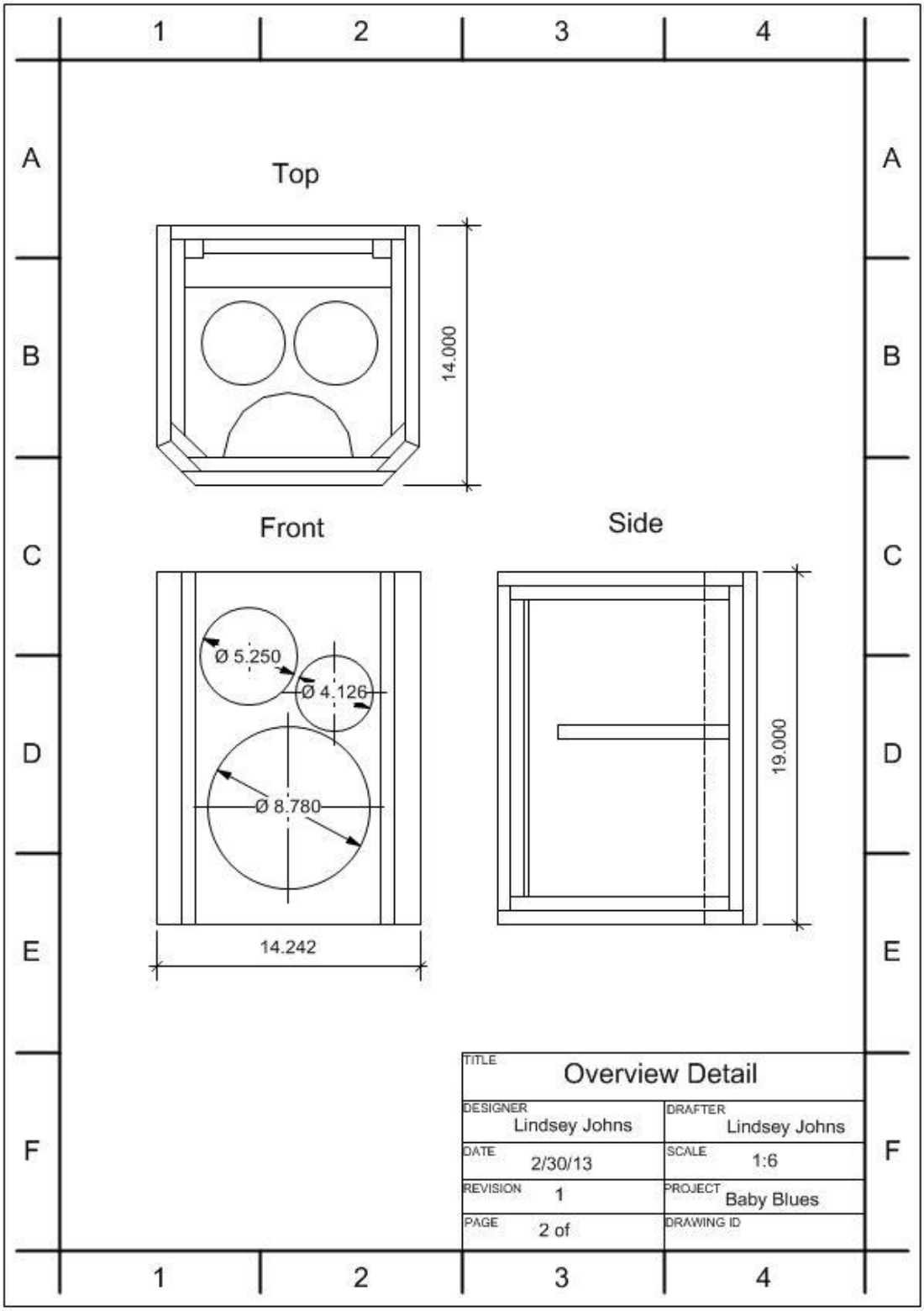


Appendix A: SPL Experiment – Full Results



Appendix B: Full Drafting

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Side
Ø 5.250
Ø 4.126
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14.242
19.000
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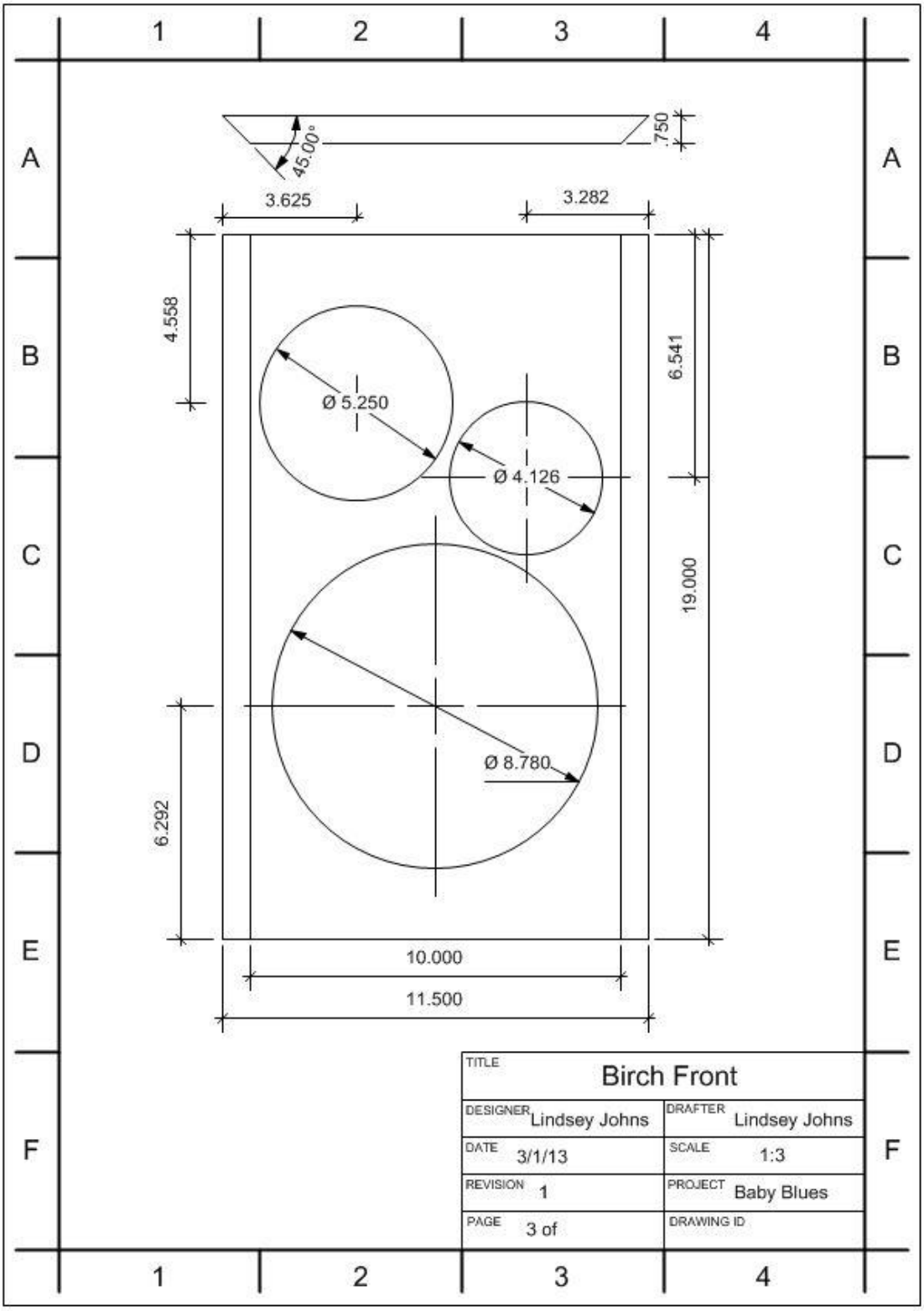
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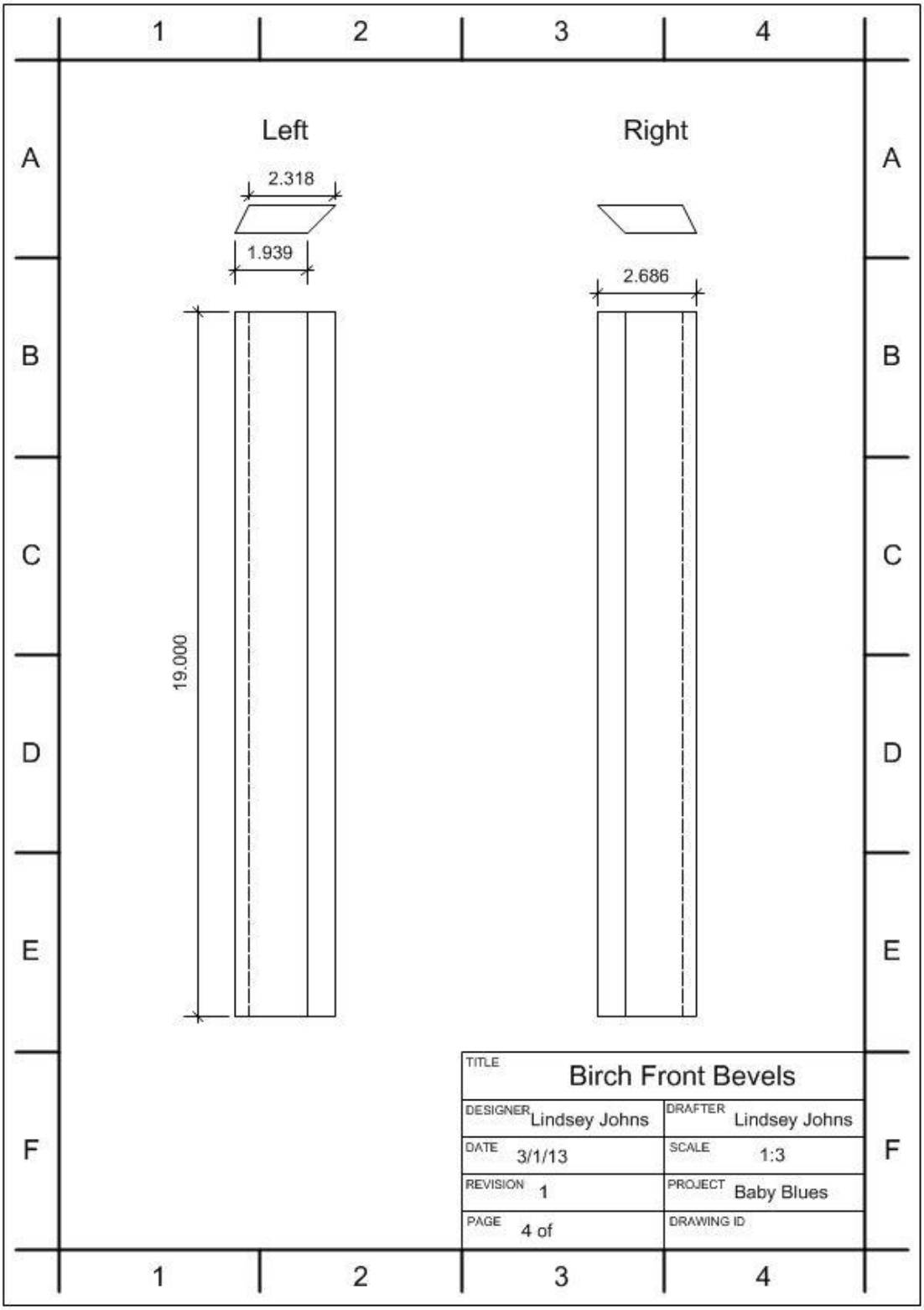
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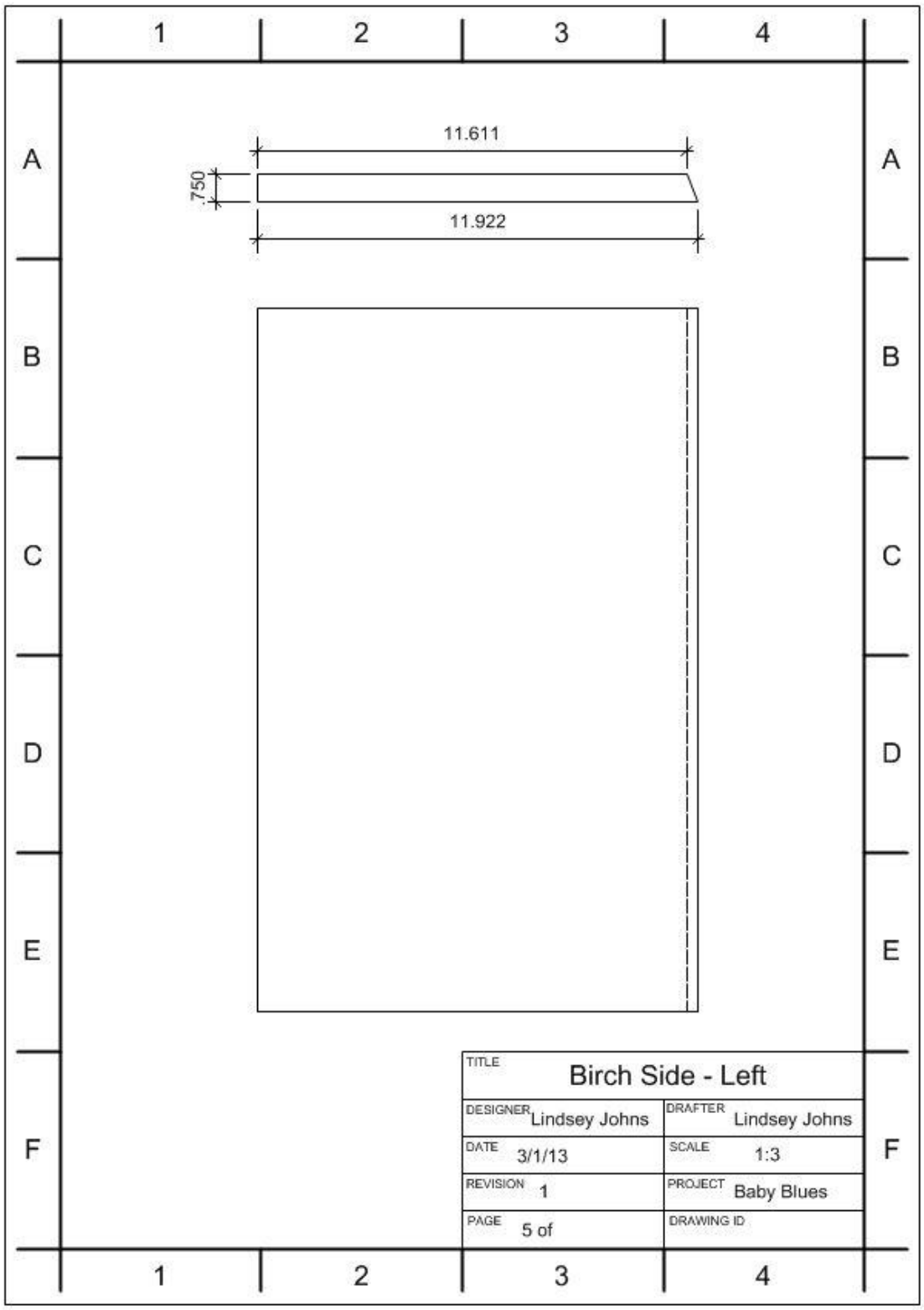
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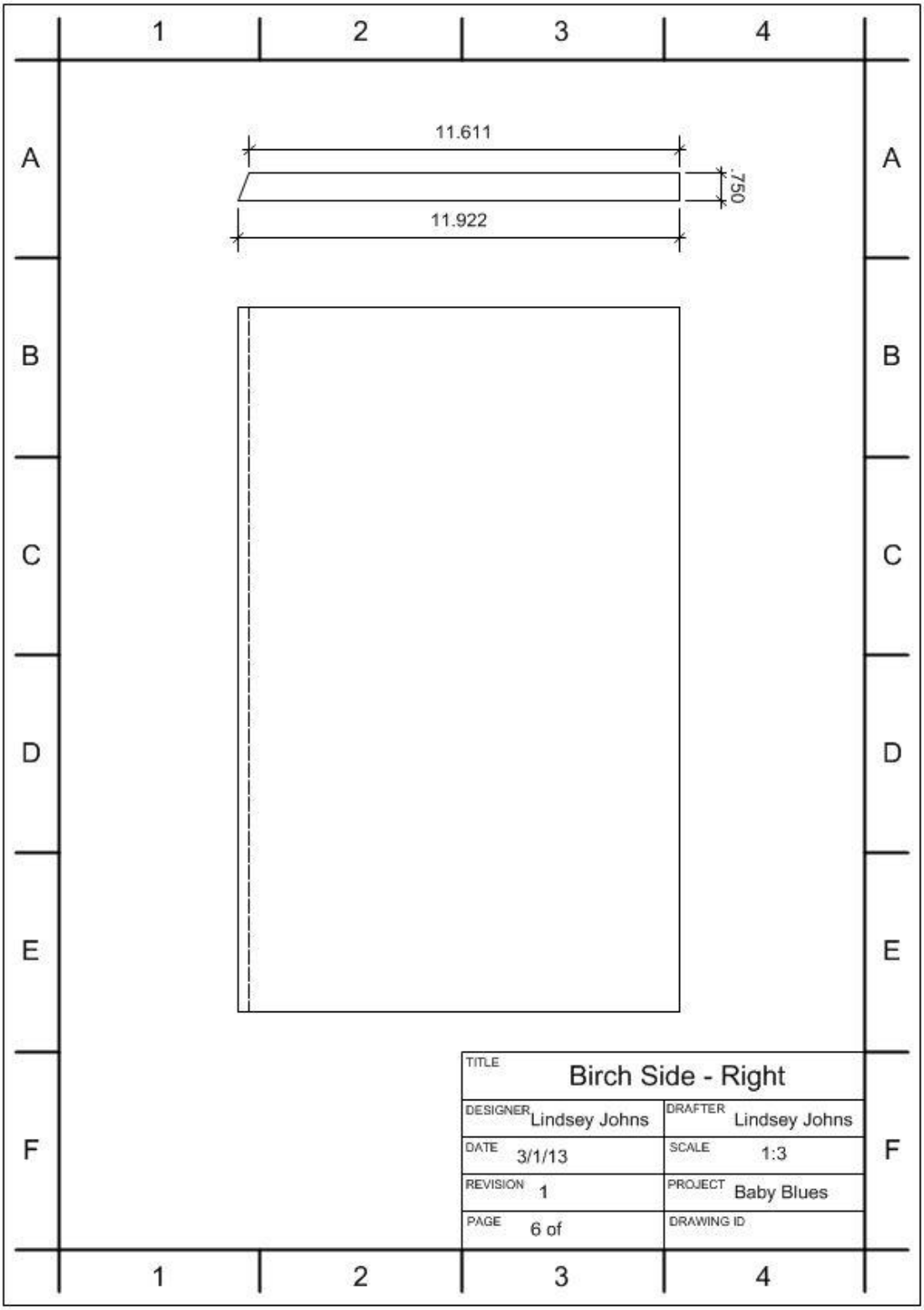
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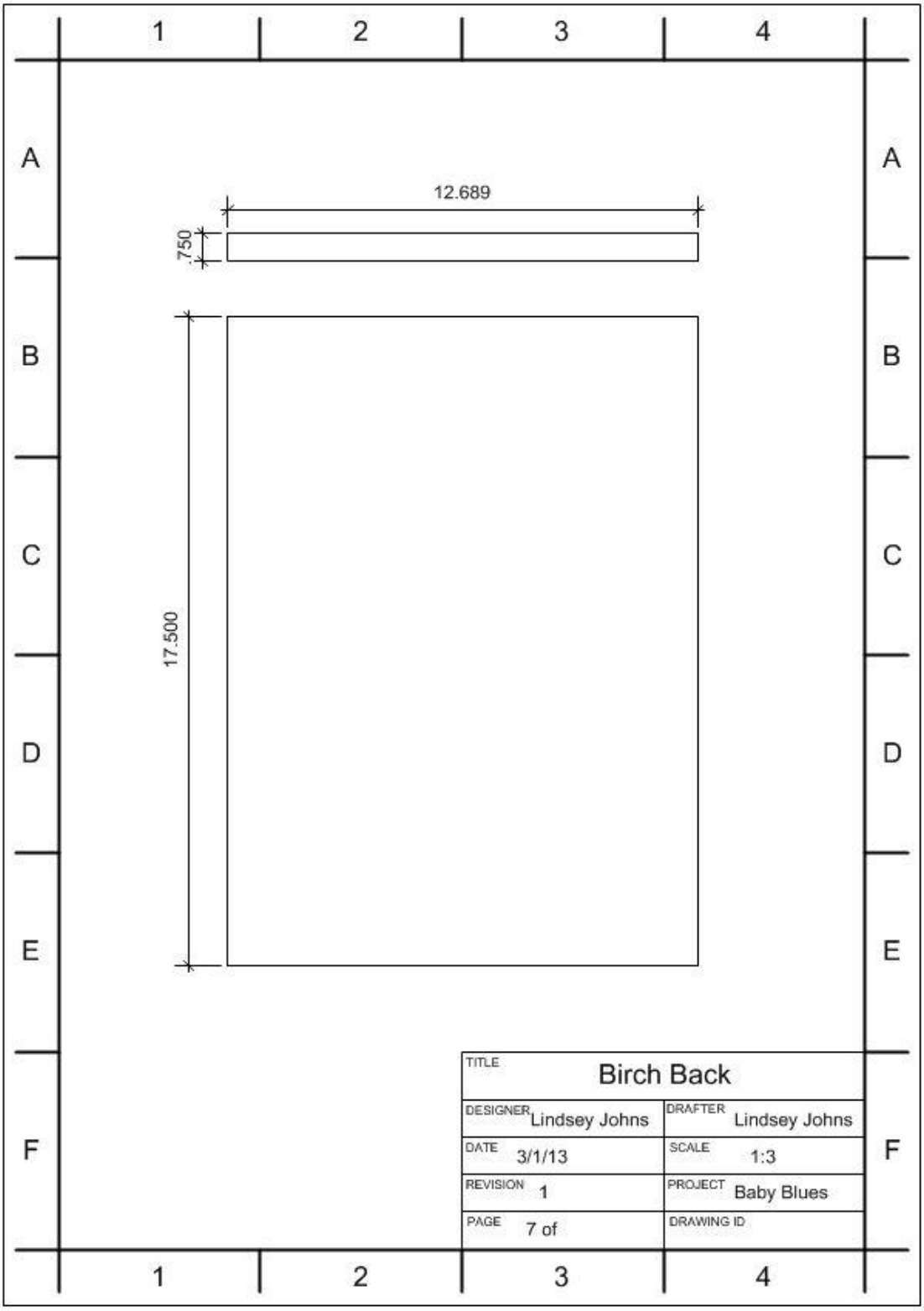
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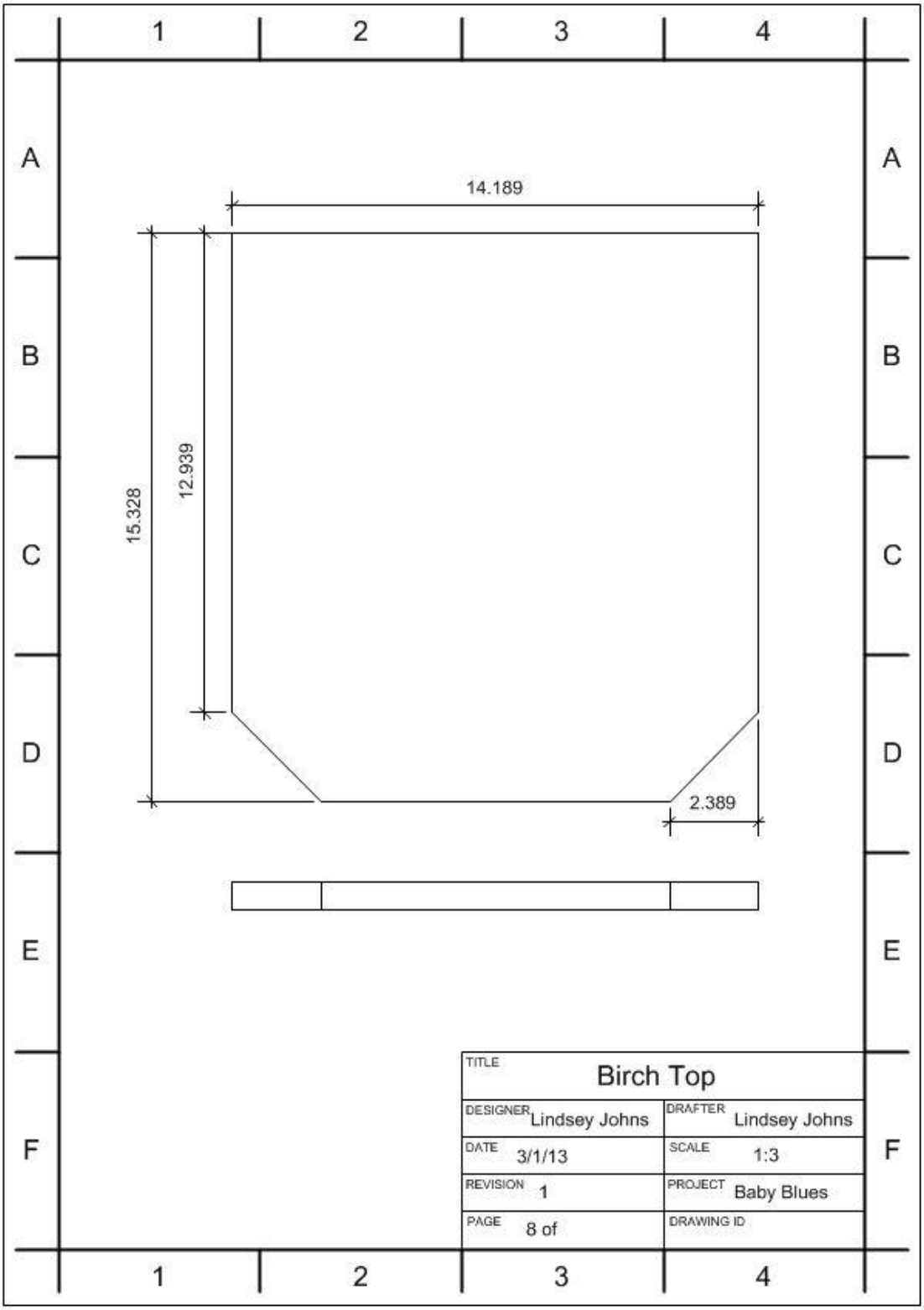
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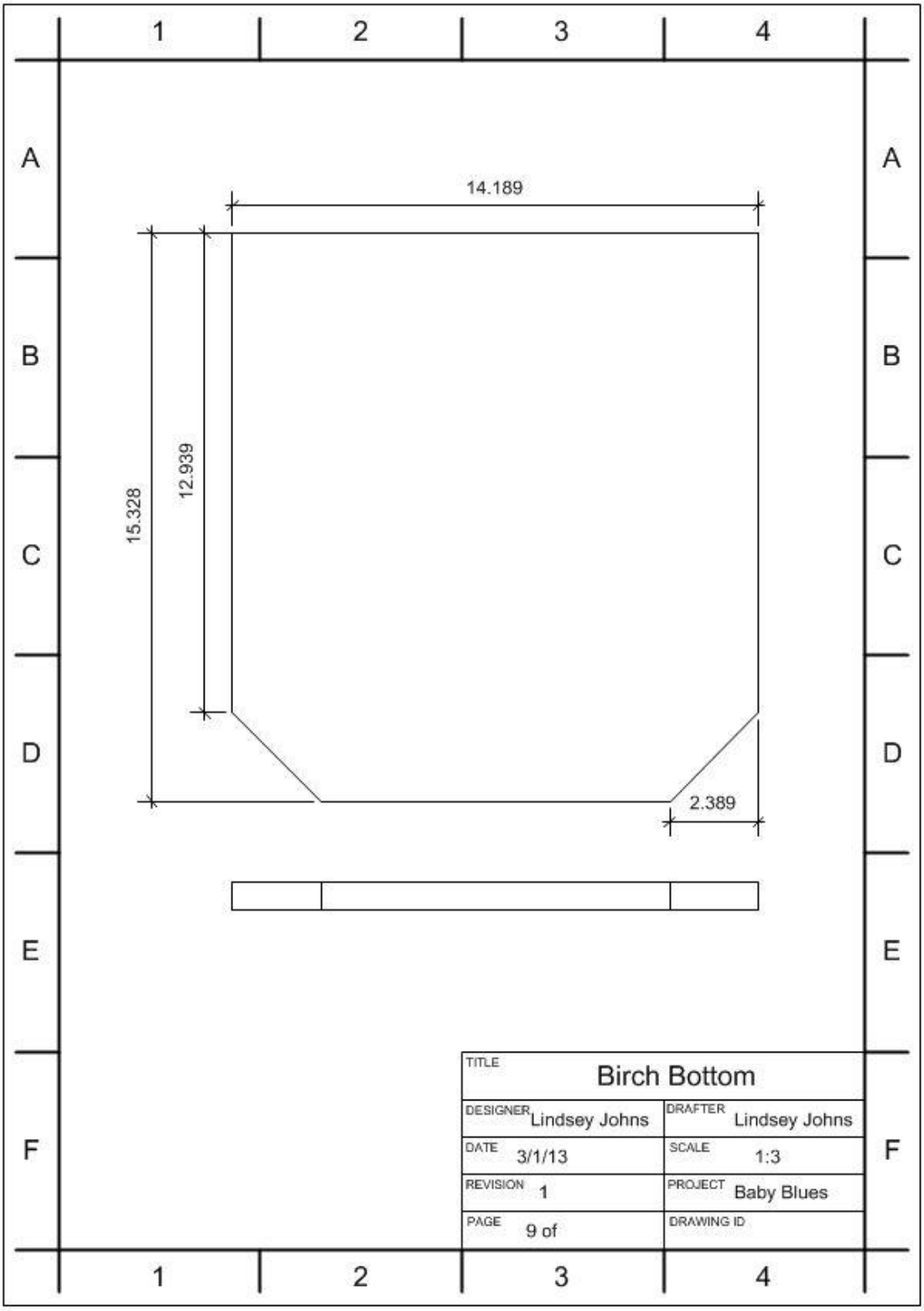
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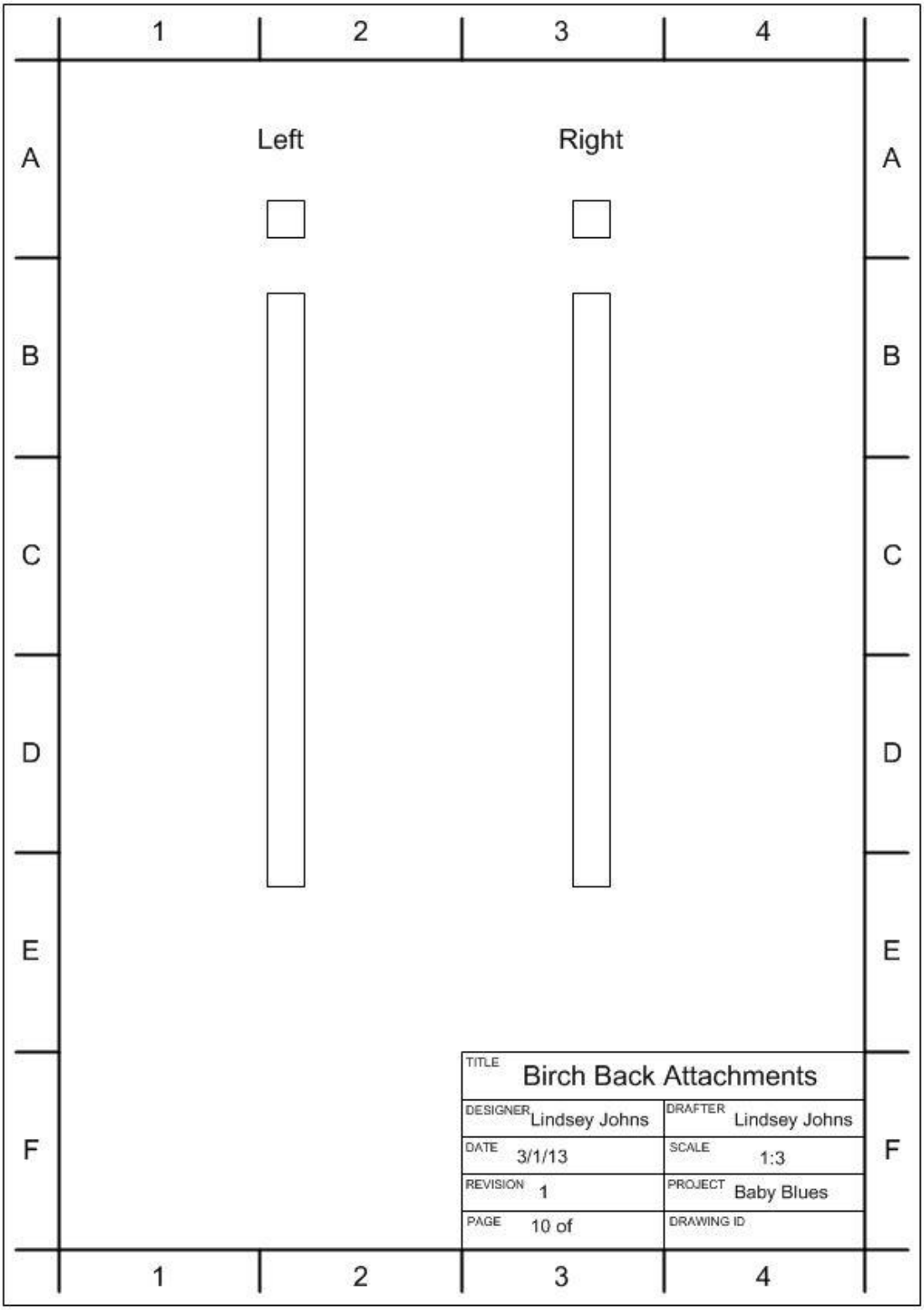
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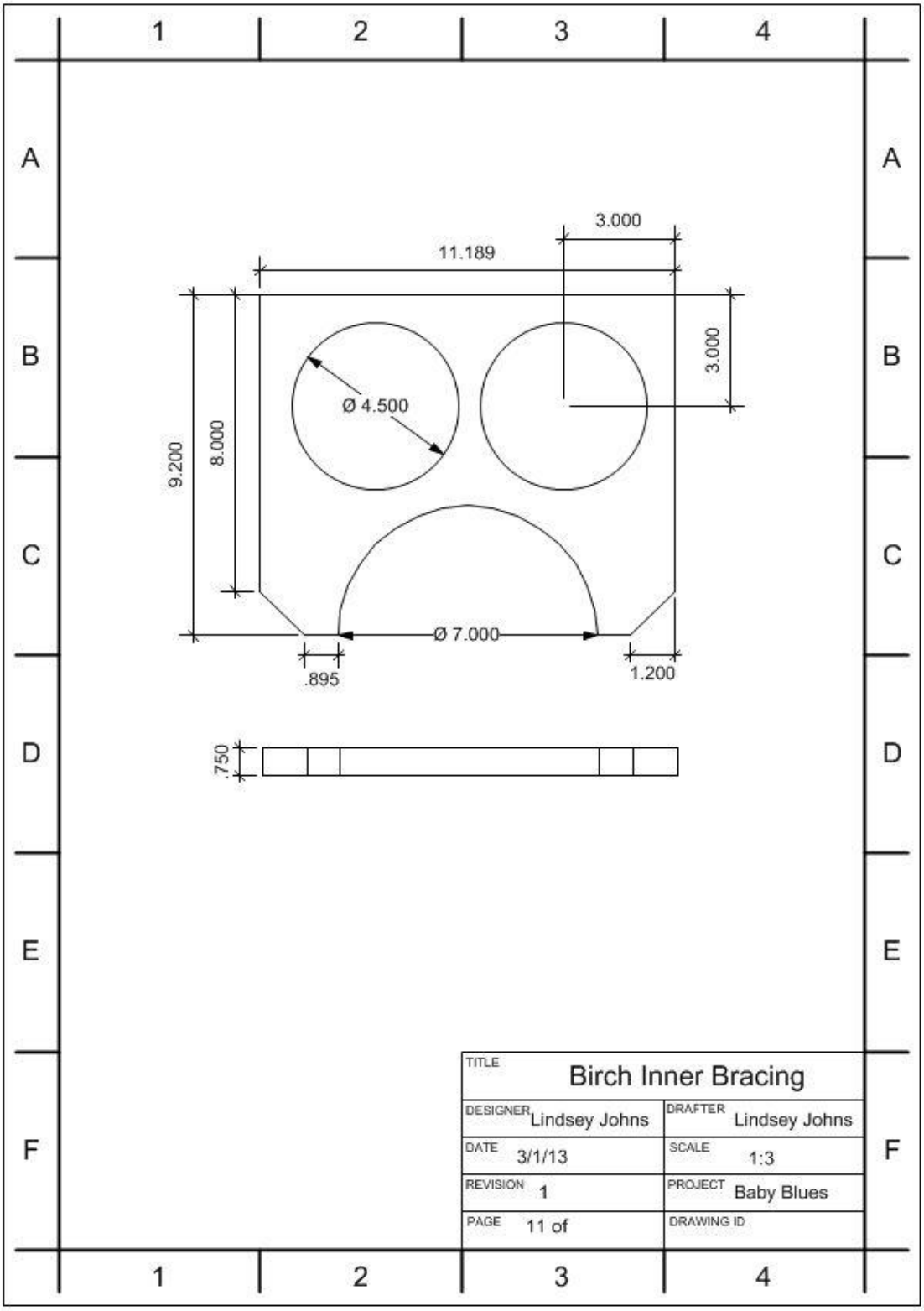
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F
3.000
11.189
3.000
Ø 4.500
9.200
8.000
Ø 7.000
.895
1.200
.750
TITLE
Birch Inner Bracing
DESIGNER
Lindsey Johns
DRAFTER
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DATE
3/1/13
SCALE
1:3
REVISION
1
PROJECT
Baby Blues
PAGE
11 of
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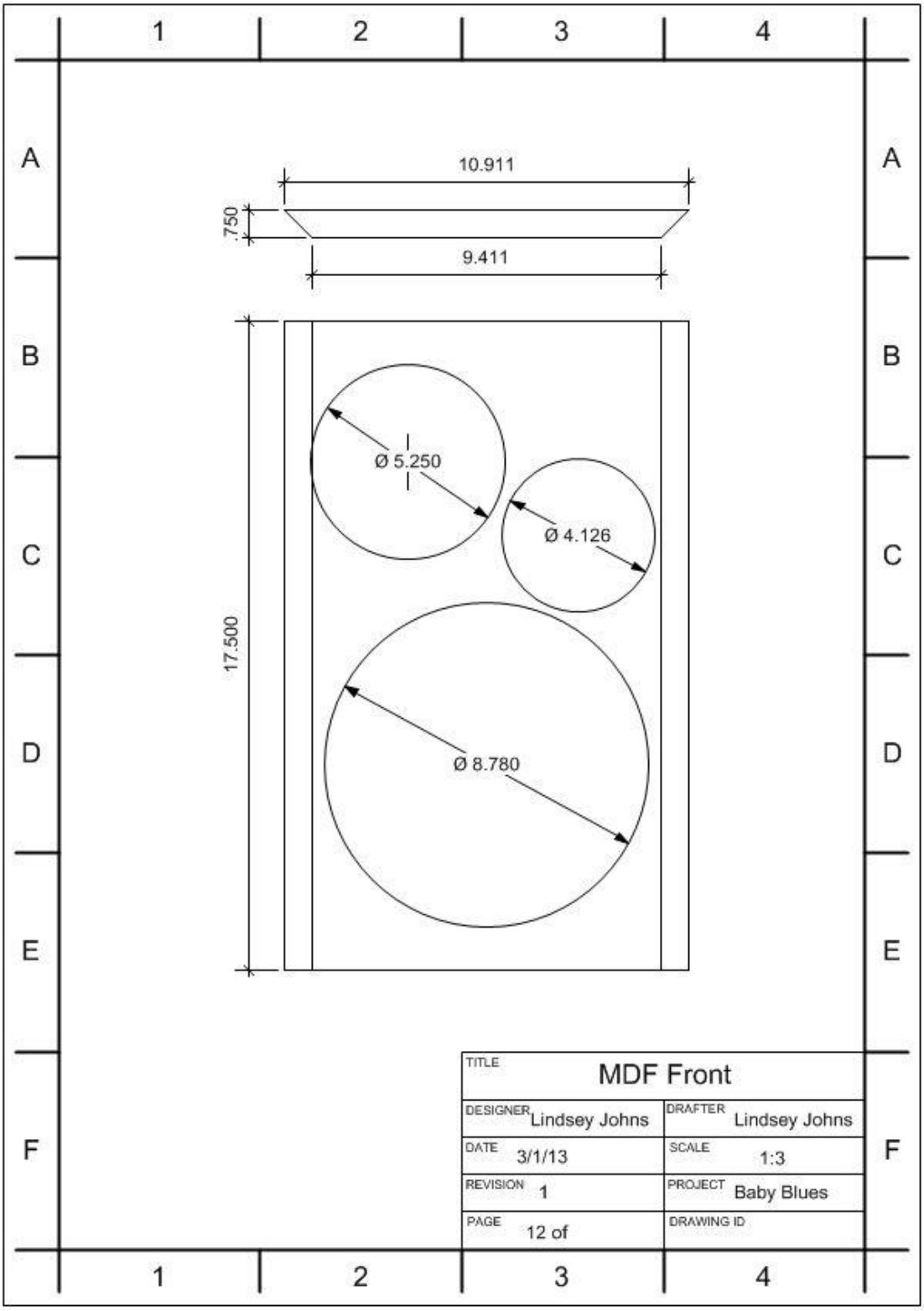
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A
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C
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Ø 5.250
Ø 4.126
Ø 8.780
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MDF Front
DESIGNER
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DATE
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SCALE
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Baby Blues
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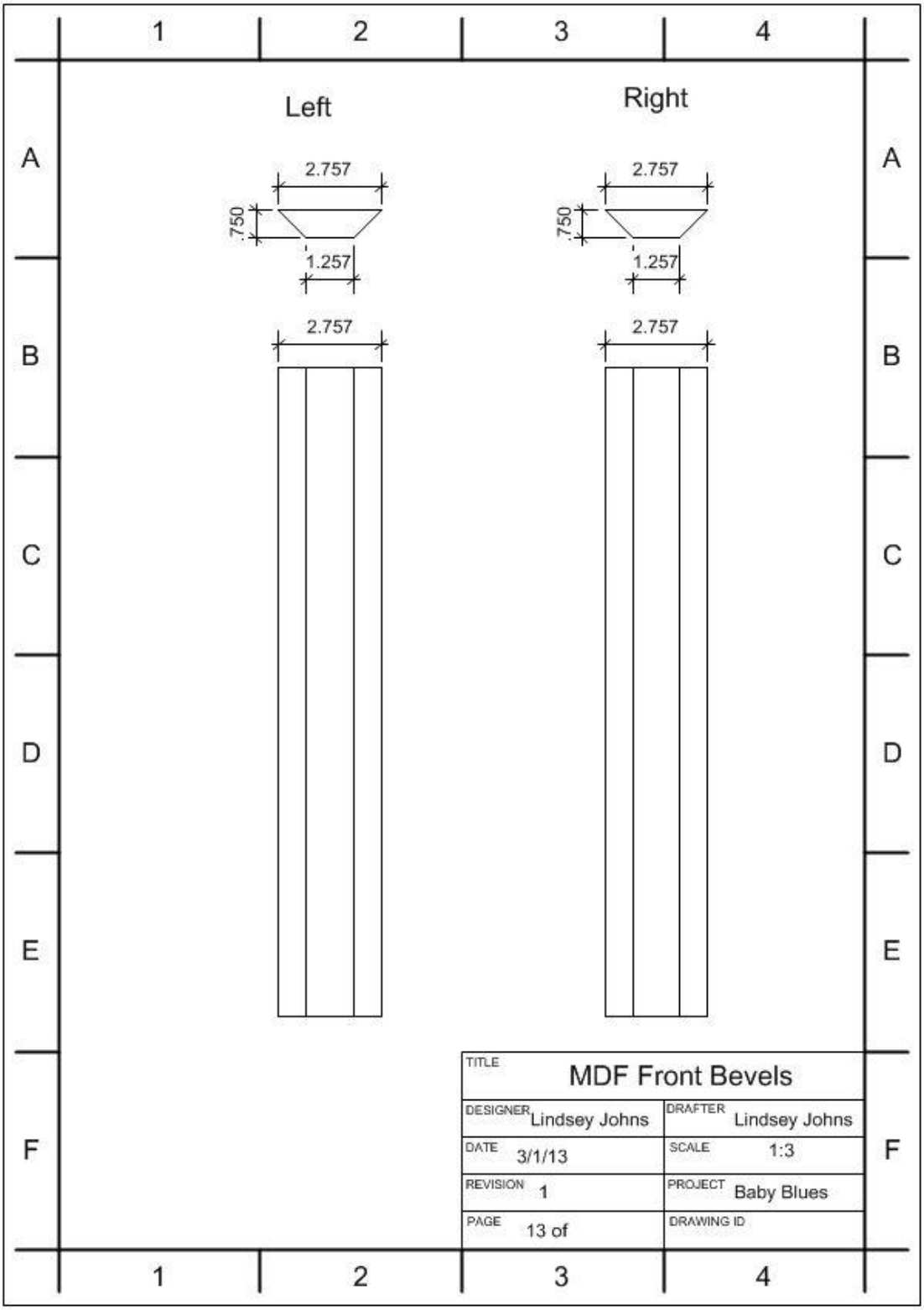
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D
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F
Left
Right
2.757
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TITLE
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DESIGNER
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DATE
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Baby Blues
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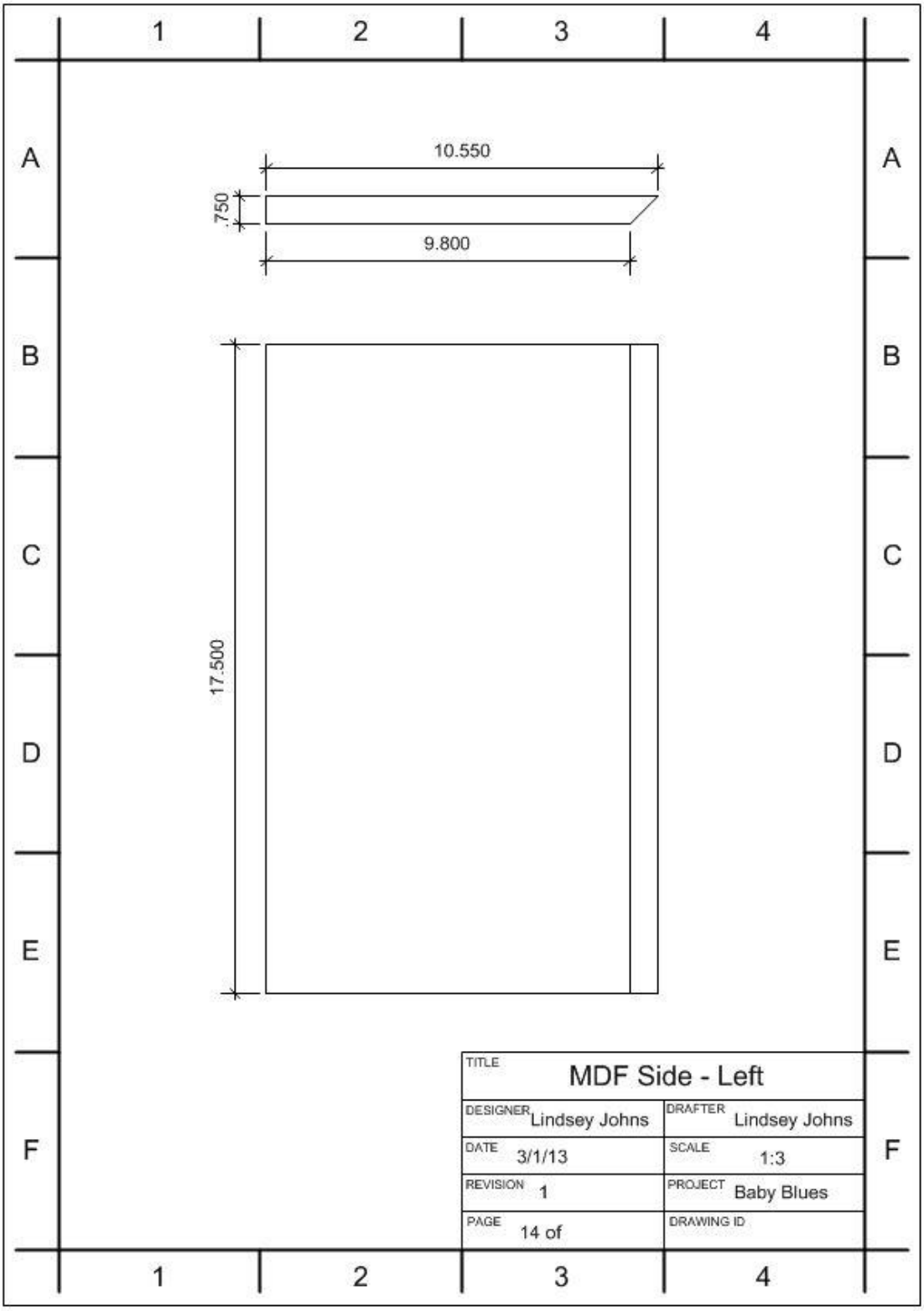
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2
3
4
A
B
C
D
E
F
10.550
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9.800
17.500
TITLE
MDF Side - Left
DESIGNER
Lindsey Johns
DRAFTER
Lindsey Johns
DATE
3/1/13
SCALE
1:3
REVISION
1
PROJECT
Baby Blues
PAGE
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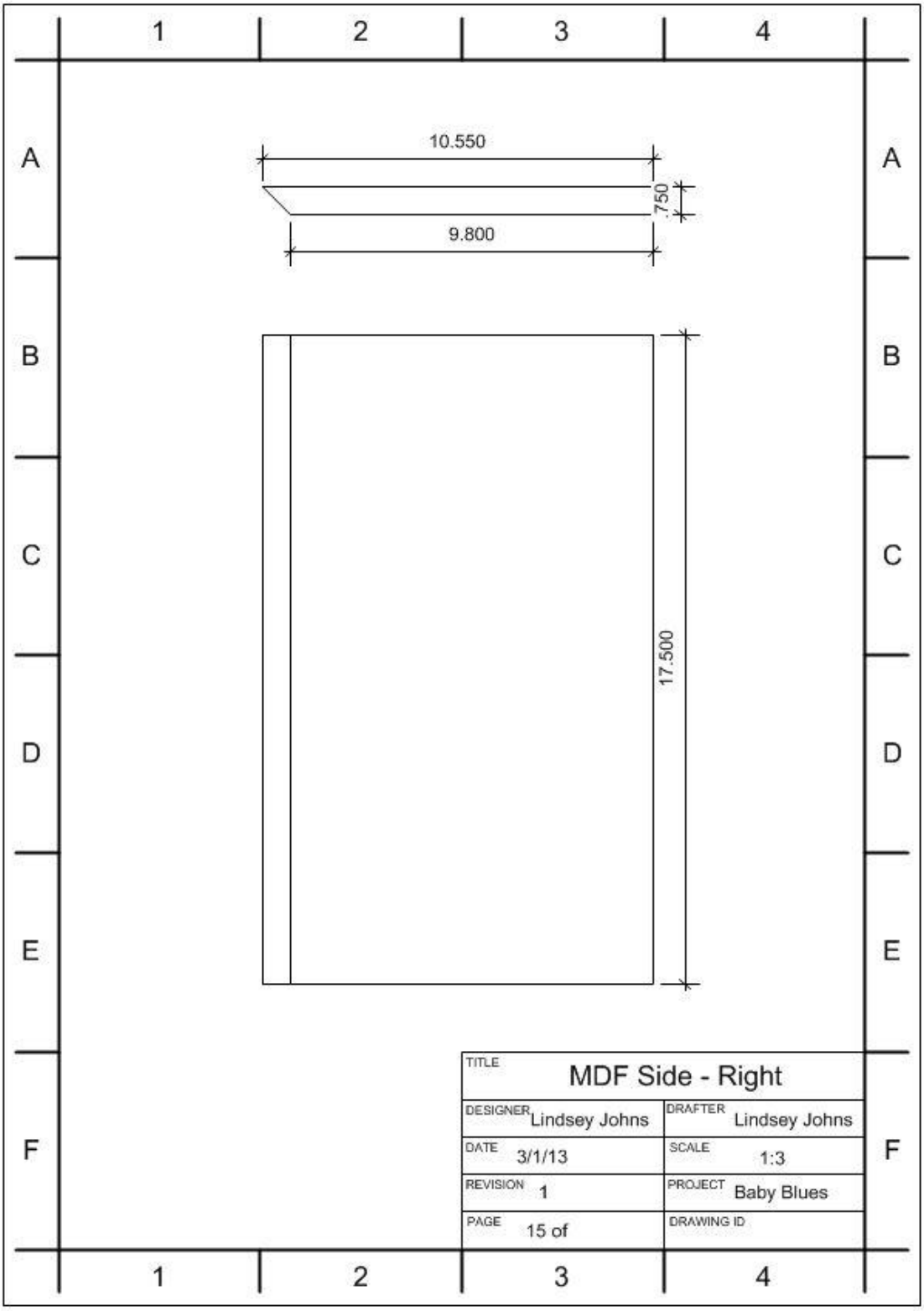
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A
B
C
D
E
F
10.550
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9.800
17.500
TITLE
MDF Side - Right
DESIGNER
Lindsey Johns
DRAFTER
Lindsey Johns
DATE
3/1/13
SCALE
1:3
REVISION
1
PROJECT
Baby Blues
PAGE
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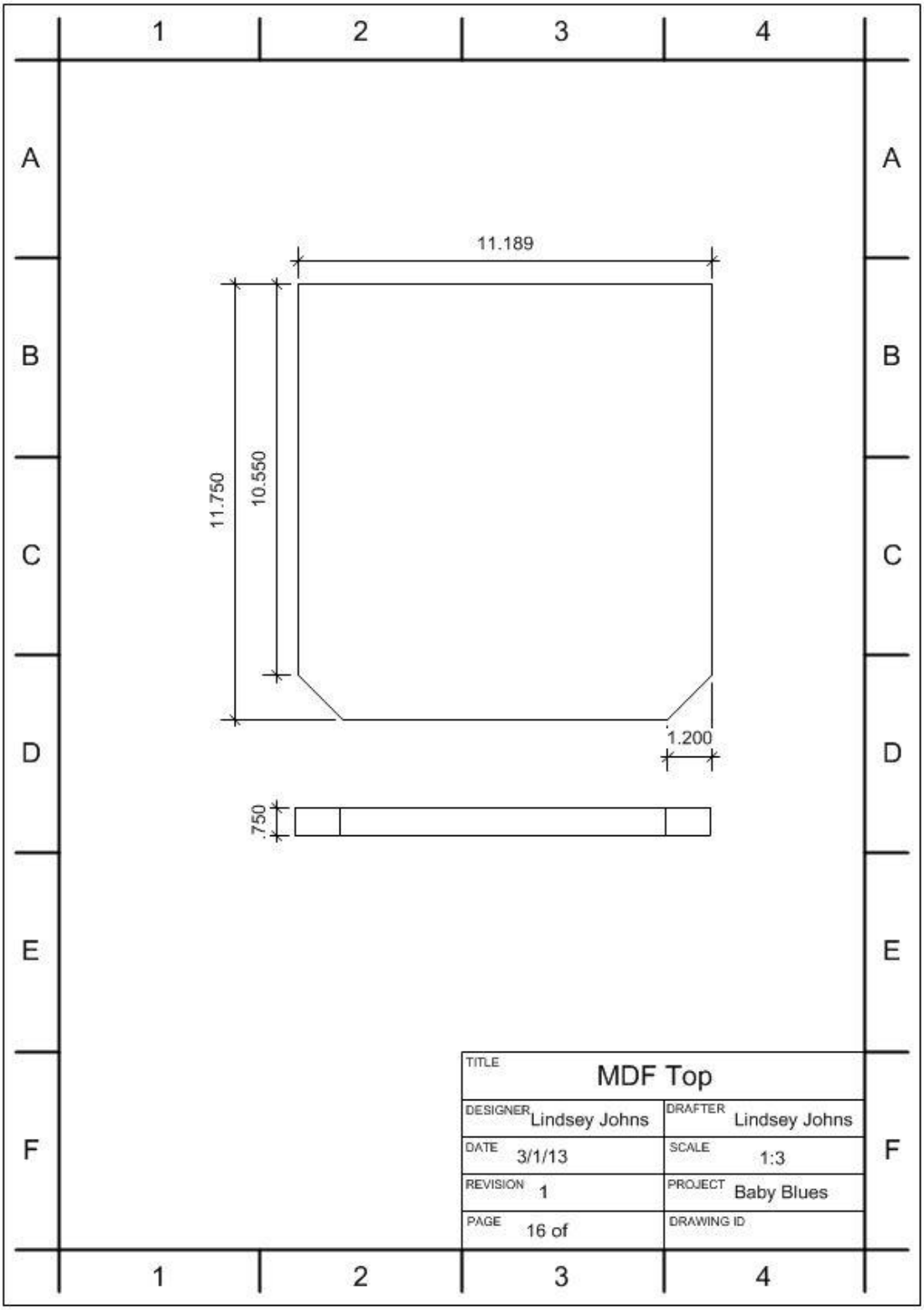
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C
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MDF Top
DESIGNER
Lindsey Johns
DRAFTER
Lindsey Johns
DATE
3/1/13
SCALE
1:3
REVISION
1
PROJECT
Baby Blues
PAGE
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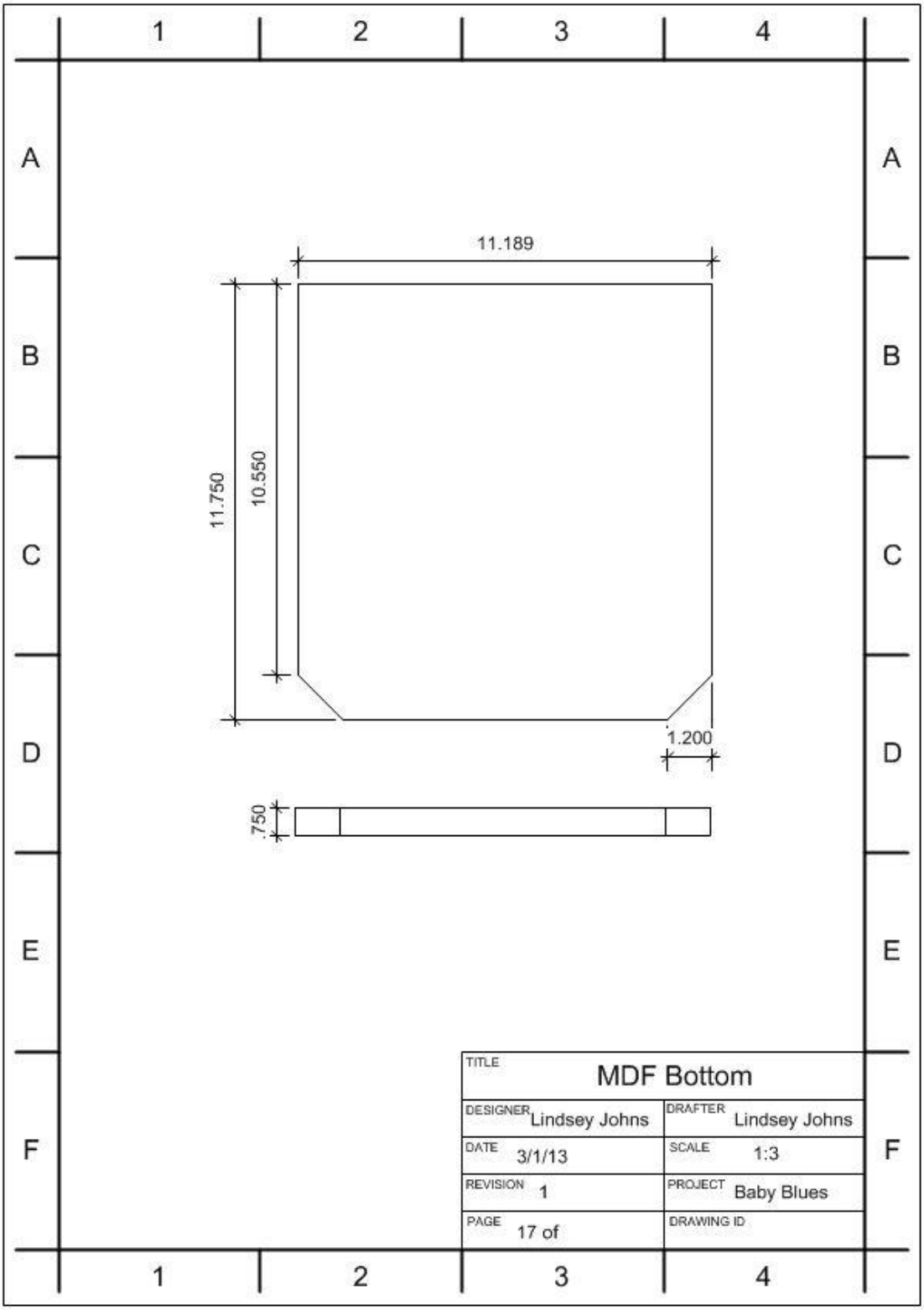
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MDF Bottom
DESIGNER
Lindsey Johns
DRAFTER
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DATE
3/1/13
SCALE
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1
PROJECT
Baby Blues
PAGE
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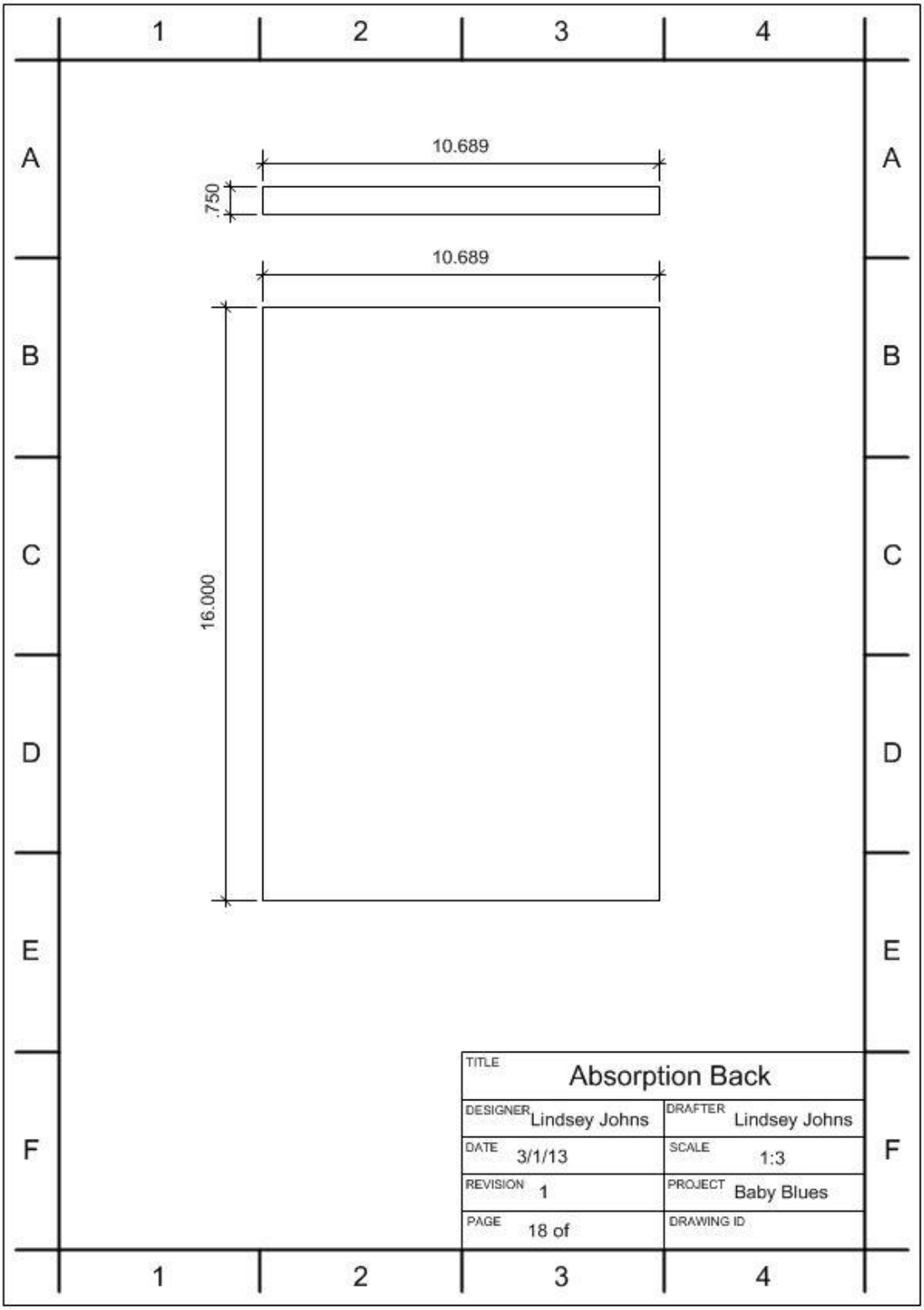
DRAWING ID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Absorption Back
DESIGNER
Lindsey Johns
DRAFTER
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DATE
3/1/13
SCALE
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1
PROJECT
Baby Blues
PAGE
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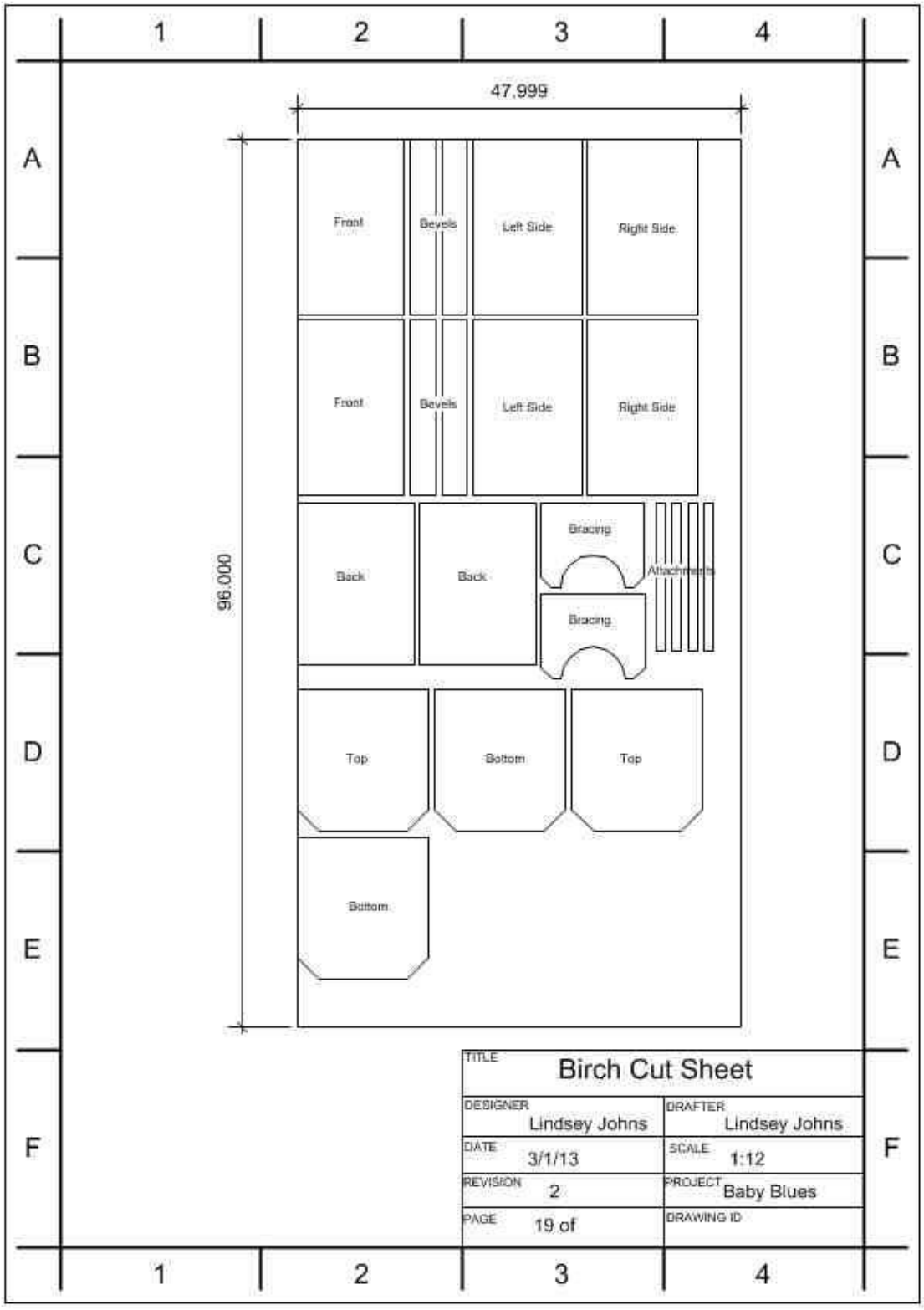
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C
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96.000
Front
Bevels
Left Side
Right Side
Front
Bevels
Left Side
Right Side
Back
Back
Bracing
Bracing
Attachments
Top
Bottom
Top
Bottom
TITLE
Birch Cut Sheet
DESIGNER
Lindsey Johns
DRAFTER
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DATE
3/1/13
SCALE
1:12
REVISION
2
PROJECT
Baby Blues
PAGE
19 of
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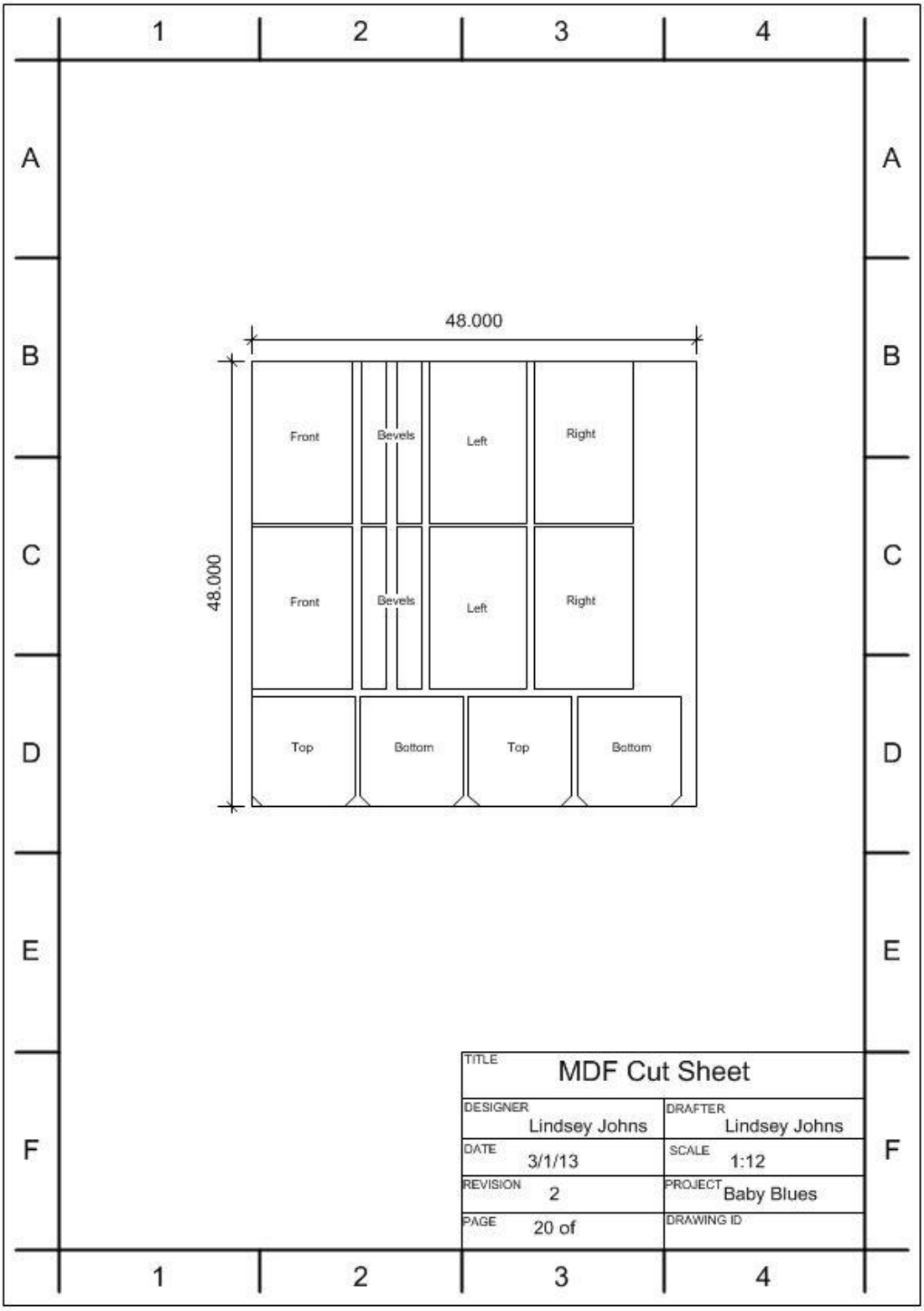
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D
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F
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48.000
Front
Bevels
Left
Right
Front
Bevels
Left
Right
Top
Bottom
Top
Bottom
TITLE
MDF Cut Sheet
DESIGNER
Lindsey Johns
DRAFTER
Lindsey Johns
DATE
3/1/13
SCALE
1:12
REVISION
2
PROJECT
Baby Blues
PAGE
20 of
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