

THE SHORT & SWEETS

Mid-Size Easy Listening Speakers



Izzy Waldie

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1.0

FUNCTIONAL DESCRIPTION

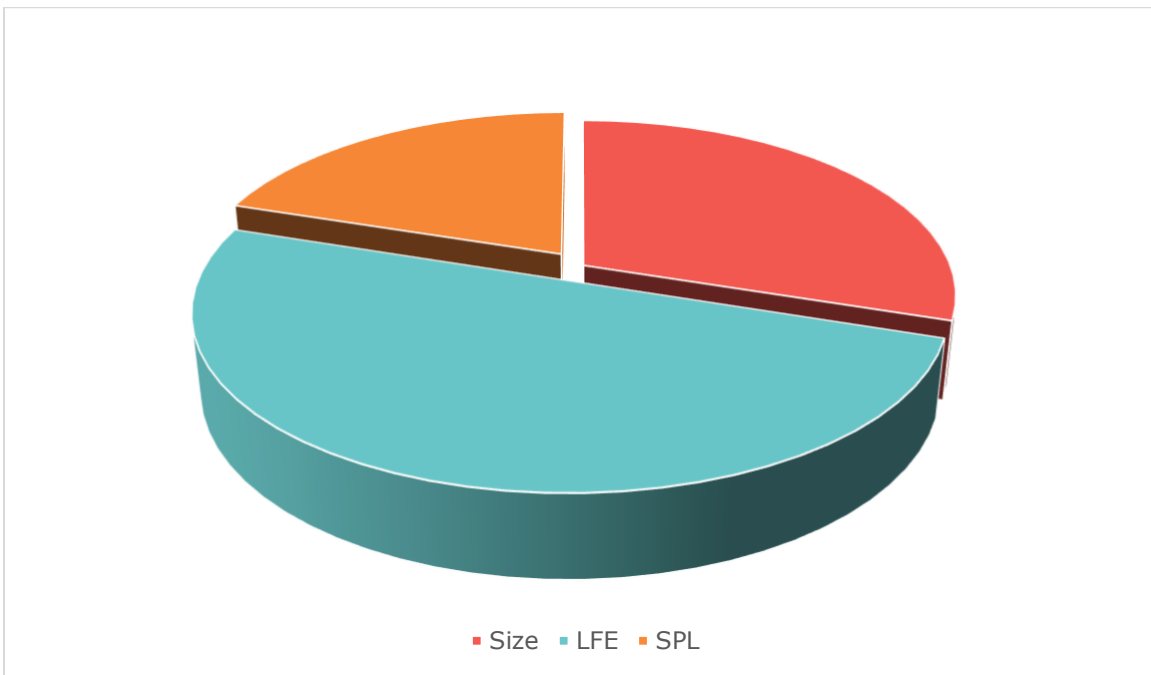
These Speakers will be of a moderate size, somewhere between bookshelf and tower that could fit into a custom bookshelf in a small apartment. These speakers will primarily be used for easy listening, with inputs including phones, laptops, CD players, and turn tables.

The speakers will be roughly 5-15 feet from the listener, and the listener will usually be outside of any desired listening position. The purpose of the speakers is to fill the room with pleasant sounding music, without focusing on one specific listening position.

Other uses for these speakers could include some low-pressure critical listening, 'party' speakers, and potentially vocal monitoring, but these are a lower priority use case.

Due to the intended use of these speakers, size is of moderate concern, low frequency extension is prioritized, and SPL needs are rather moderate.

Based on John L. Murphey's recommended 3-point tradeoff, this speaker will prioritize low frequency extension first, size second, and SPL output last. ¹



¹ John Murphy, *end.* P. 55.

2.0

REFERENCE SYSTEMS

2.1 OVERVIEW

	F3	SPL Peak	Weight (per spkr)	Dimensions (in)	Price (USD, pair)
<i>PSB passif50</i>	30		30.3 lbs	26x11x10	2,499
<i>Klipsch Pines</i>	22	115	28.4	19.13x9.5x13.38	1,499
<i>BW 606S3</i>	40		15.5	13.6x7.4x11.8	1,100
<i>Elysian 2</i>	<35		67.2	27.6" x 13.1" x 17.0"	6,995
<i>KLH Model 3</i>	35	108	29	28.25x12.25x11.5	1,798

A review of mid-size bookshelf speakers that have a low frequency extension at least down to 40Hz was done to determine the general performance of this market segment.

Looking over these reference speakers, quite a few of them lack a spec on peak SPL output, but that is of minor concern. The Elysian2 did not have an F3 spec, but 35Hz was listed as the bottom value in the +/- 3dB frequency response, so the F3 can be assumed to be lower than that. Dimensions of roughly 27x12x14 seem the most common. The Klipsch Pines surprisingly have the lowest F3 with a smaller box-size.

2.2 SPECIFIC LOUDSPEAKERS

PSB Passif 50²



First of all, I think these are gorgeous. The Passif 15 loudspeakers by PSB speakers is a 2-way with a passive radiator. These speakers are attractive to my needs because of their size and low frequency extension (down to 30Hz). Specs state that it has a flat frequency response (+/- 3dB) from 50Hz to 20kHz.

The retail price on these is \$2,499

(yikes!). I like the idea of the passive radiator, as it allows for a frequency response that extends lower than if sealed, but has the potential to keep things from sounding 'muddy'.

SPECIFICATIONS

PASSIF 50

Frequency Response	
On Axis @0 +/- 3db	50-20,000kHz
On axis @0 +/- 1 1/2db	70-16kHz
off Axis @ 30 +/- 1 1/2db	70-10,000Hz
LF Cut Off @0 - 10db	30Hz
Sensitivity	
Anechoic	87dB
Listening Room	89dB
Impedance	
Nominal	6 Ohms
Minimal	4 Ohms
Input Power	
Recommended	30-200 Watts
Program	200 Watts
Acoustic Design	
Tweeter	1" (25mm) titanium dome with ferrofluid and neodymium magnet
Woofer	6.5" (165mm) cast aluminum basket, paper cone, and filleted rubber surround
Crossover	1800Hz, LR4
Design Type	2 way with passive radiator
Dimensions	
Size Without Stands (WxHxD)	26" x 11" x 10" 660mm x 280mm x 254mm (26" x 11" x 10")
Size With Stands (WxHxD)	870mm H x 280mm W x 254mm D (34" x 11" x 10")
Net Weight	30.3 lbs (13.7kg) per speaker
Gross Carton Weight	48.5 lbs (22 kg) per speaker

² <https://www.psbSpeakers.com/product/passif50/>

Klipsch – The Nines³

I was drawn to these speakers because of the combination of small box size and impressive low-frequency extension. They are also very pretty. They are an active two-way loudspeaker. "Dynamic Bass Extension" is listed at 22Hz, with a +/- 3dB frequency response at 34Hz-25kHz.

SPECIFICATIONS	
SYSTEM DESCRIPTION	Powered Monitor (pair)
FREQUENCY RESPONSE	34-25kHz +/- 3dB
DYNAMIC BASS EXTENSION	22Hz @ 35% Volume
MAX OUTPUT	115 dB (1M Stereo Pair)
TOTAL SYSTEM POWER	240W Total System Power (480W Peak) 100W LF, 20W HF
HIGH FREQUENCY DRIVER	1" (2.5cm) Titanium LTS vented tweeter with Tractrix [®] horn
LOW FREQUENCY DRIVER	8" (20.32cm) high-excursion fiber-composite cone woofer
ENCLOSURE MATERIAL	MDF with genuine wood veneer
ENCLOSURE TYPE	Bass-reflex via rear-firing port
INPUTS	<ul style="list-style-type: none">• HDMI-ARC with CEC• Bluetooth[®] 5.0 wireless technology• Phono/Line analog (with switch and ground screw terminal)• 3.5mm analog mini jack• USB digital• Optical digital
OUTPUTS	Single RCA line level output for connection to subwoofer
HEIGHT, WIDTH, DEPTH	19.13" (485.8mm) x 9.5" (241.3mm) x 13.38" (339.7mm)
WEIGHT	Primary: 28.4 lbs (12.88kg) - Secondary: 27.0 lbs (12.25kg)
FINISH	Walnut / Black
VOLTAGE	100V-240V 50/60Hz internal power supply with region specific power cords
INCLUDED ACCESSORIES	<ul style="list-style-type: none">• Region-Specific power cord (2.0m)• Remote control (with 2 x AAA batteries)• 4-conductor speaker cable (4m)• 4-conductor speaker cable extension (2m)• USB Type-B to USB Type-A cable (1.5m)• HDMI Cable (1.5m)



³ <https://www.klipsch.com/products/the-nines-powered-speakers>

Polk RTA 12B

These are my current favorite speakers in both aesthetics and audio quality. These are the original reason I was drawn to passive radiators. They have a flat frequency response (+/- 3dB) at 50-20,000 Hz. "Polk uses a pair of small (5-1/2-inch) laminated-polymer cone drivers for the bass and

much of the midrange. The drivers, which are identical, operate together up to 600 Hz; one then rolls off while the other is used up to 2,000 Hz. The two drivers are in a large enclosure with a "Vent" consisting of a 12-inch flat-diaphragm passive radiator. The purely acoustic crossover between the driven and passive radiators takes place at 60 Hz."⁴ I would love to create something similar to these with modern technology.



⁴ <https://www.hifi-classic.net/review/polk-audio-rta-12b-339.html>

3.0

TECHNICAL SPECIFICATIONS

3.1 OVERVIEW

These speakers are meant to fit into a bookshelf and 'fill' a small apartment with music. Bookshelf will not be too restricting in size as it will be custom made to allow these speakers the proper space. SPL and frequency requirements for these speakers lie mostly in the realm of 'easy listening', with hopes of a slight smile curve in frequency response, and a LFE down to 60Hz. The option of pairing these speakers with an active sub is still being considered, but relying on the sub-woofer for all low frequencies is something I am trying to avoid (maybe the sub would only be used in certain situations -like a party- where fidelity is sacrificed for the ~vibe~). Because of the lack of a specific listening position, the listening axis and distance will vary greatly, a nice frequency response at many different angles is desired, but most importantly how the off-axis responses all sum together in the room needs to be enjoyable.

3.2 CABINET DESIGN

For these speakers, I am going of a middle-of-the-road size, not as small as a typical bookshelf, but not quite as large as a tower. Being somewhat portable would be great, simply for the purpose of moving, but once installed these speakers will mostly stay in place.

The listening axis of these speakers should be a wide range. They are intended to be listened to while moving about, cooking, cleaning, doing yoga, etc... An ear-level of about 5'4" will be the most used, but other levels must be considered, such as 'in bed' level at ~4' and 'sitting on the floor' level at ~2'.

To the left is an example room layout with 2 possible stereo locations.

There is a high probability that these speaker cabinets will be surrounded on all sides (except front, example on the right), so if any port/vent is going to be added, it will need to be on the front.



3.3 SPL

These speakers will primarily be used to listen to music on Spotify (hopefully Tidal eventually), vinyl records, and CD's. I will allow for a minimum of 20dB headroom above my average listening level to account for peaks.

Average listening level for what these are intended for is around 82dB at 1 meter, so I will need the ability to peak at 102 dB.

3.3 FREQUENCY RESPONSE AND EXTENSION

Based on our listenings in lab, I really want the 40Hz zone as the ~magic bass~ zone. I want the speakers to be flat down to at least 38Hz, but the closer I can get to 30Hz the better.

4.0

DESIGN

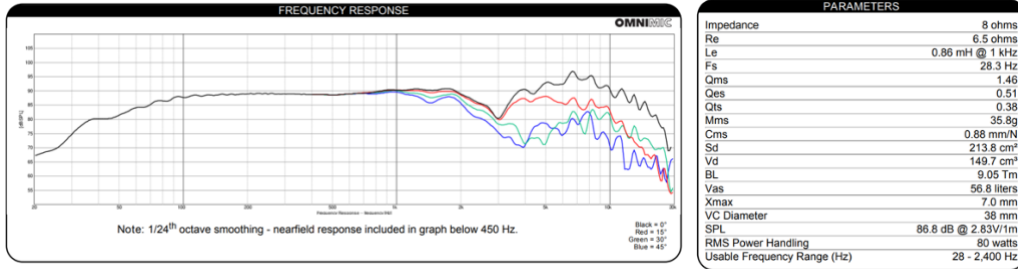
4.1 DRIVER SELECTION

Woofer: Dayton Audio Reference series 8-inch woofer

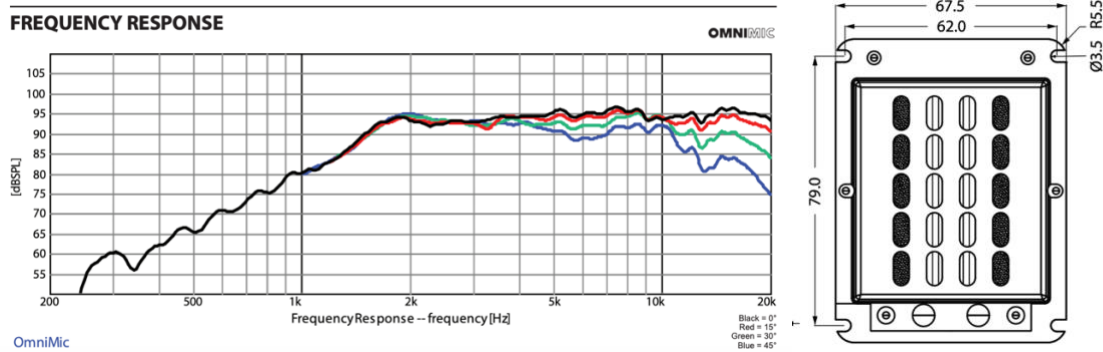
I chose this woofer primarily because it seemed to offer the most 'bang for my buck', I debated between the 6,7,and 8 inch, but after my calculations in WinSpeakerz I saw that the 8 inch would give me a sizable amount of low frequency extension for a less than dramatic price increase (especially in a not-that-big box). Anything bigger than 8 inches I was afraid would struggle to crossover with a tweeter well.

The aluminum cone was appealing to me because, from my understanding, you can get more tightness/attack/punch from an aluminum come as compared to a fabric cone. The one thing to watch out for is crossing over well before the breakup frequency.





Tweeter: GRS PT2522C-4 3-1/2" Planar Tweeter with back cup 4 ohm



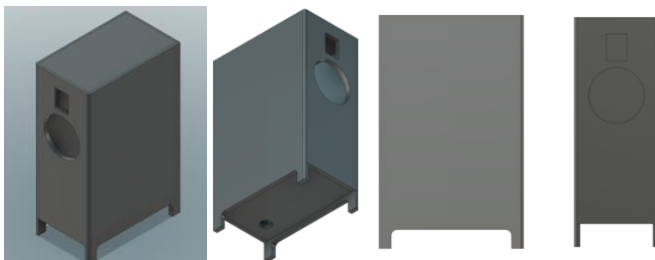
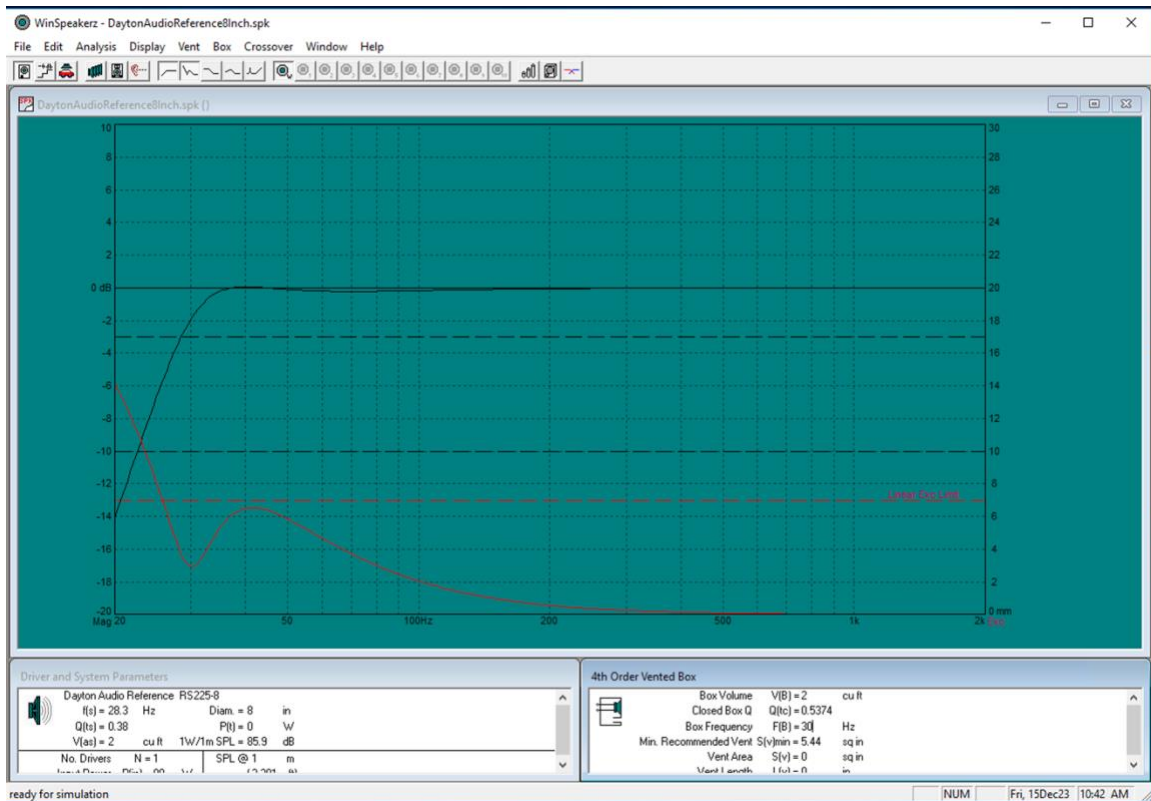
I had a hard time finding a tweeter that I felt confident crossing over at 1.8kHz. Due to its larger diaphragm, this planar tweeter is flat down to around 1.7kHz and then rolls off rather smoothly into the low end. These are meant to be replacement for a discontinued tweeter: the 'B&G Neo3s'. Luckily I was able to listen to a pair of these, and they handled the high frequency 'crispies' in Bon Iver's remixed version of Brittany Howard's song "short and Sweet" rather well.

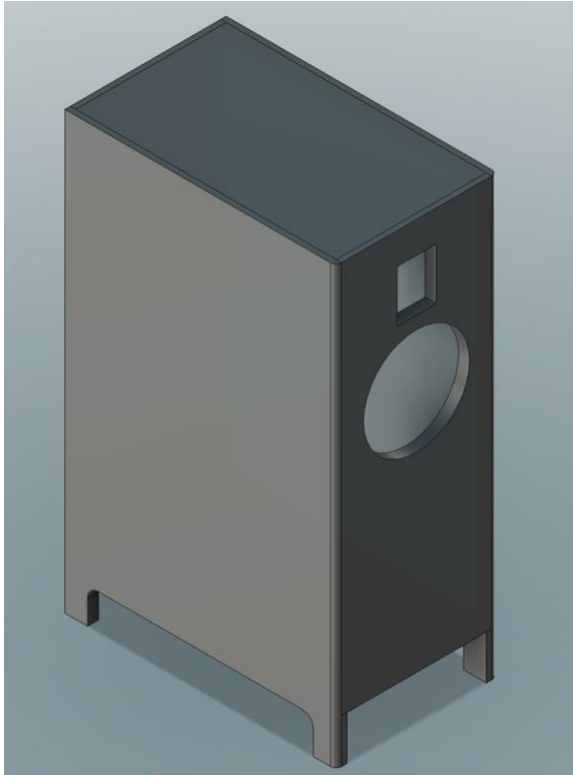
4.2 CABINET DESIGN

Net internal volume = ~ 2.36 cu. Ft

- *0.36 cubic feet added for driver and bracing displacement*

Internal dimensions: H 25.25 in W 9.5 in D 17 in





Design choices:

- Feet allow port to be on the bottom of the cabinet, which in turn allows speaker to be surrounded on all sides (small apartment consideration, can be against a wall)
- Feet also look ~cool~
- Listening level is for a person sitting on the floor/beanbag, can be set on a shelf to raise axis
- Plan to add wedges on the inside of the side walls to make them not parallel to help with resonances + bracing.

4.3 COMPONENTS

Woofer: 2x Dayton Audio Reference series RS225-8 8" woofer

Tweeter: 2x GRS PT2522C-4 3-1/2" Planar Tweeter with back cup 4 ohm

DSP: Dayton Audio DSP-408 4x8 DSP

Terminals: 2x Parts Express Bi-Amp speaker terminal

Amps: 2x Fosi Audio TPA3116 50W per channel

5.0

CONSTRUCTION

5.1 CONSTRUCTION

These speakers were built over Thanksgiving break in my parents garage.

Material: 13-ply Baltic birch plywood

Challenges:

- *Attempting fine carpentry with harbor freight tools...*
- *Not having proper tools/jogs (DIY'd a circle jig for driver holes)*
- *It was pretty chilly*

Wedges for the inside walls:

One decision I wanted to make was to make the side walls un-parallel, rather than doing a trapezoidal box I added



wedges to the inside, hoping that this would also serve as bracing. On the inside of the cabinet, there is a wedge of plywood on each side wall, starting at 1.5 inches at the base, slanting to nothing near the top.

To do this I made a little jig that allowed me to send two pieces of plywood screwed together through a planer at an angle.

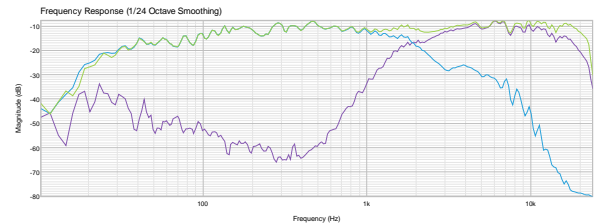


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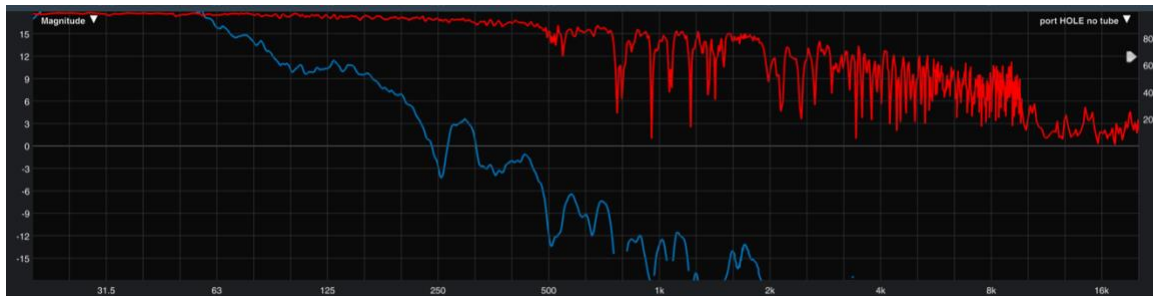
TUNING

6.1 TUNING DECISIONS

After looking at the measurements of my drivers, and seeing the very low distortion on my woofer, I decided on a crossover frequency of 2000Hz. Changing the length of my port was not giving the result I wanted, I was then advised that I can just not have a port at all! Leaving just the port hole/vent with no port tube gave me the frequency response I wanted (after a fair bit of EQ in the DSP).



Port hole with no tube:



6.2 FINAL MEASUREMENTS

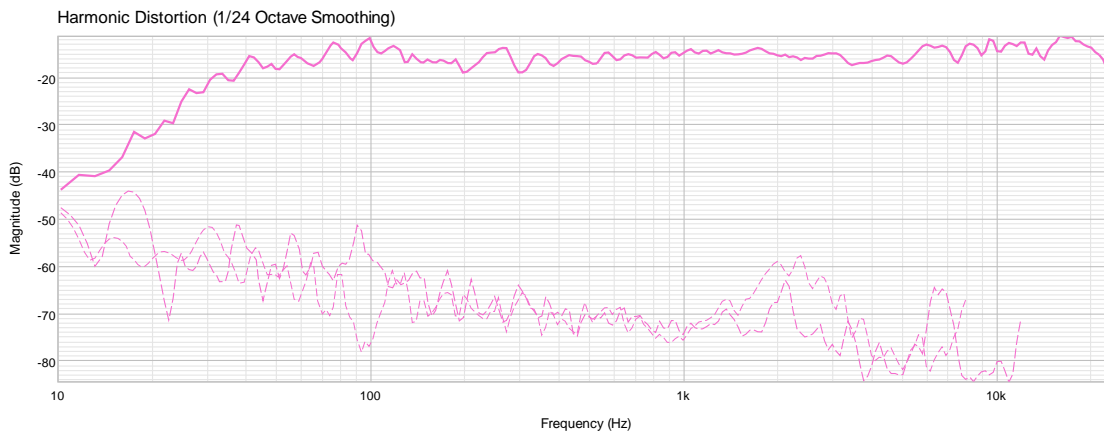
All in all, these speakers ended up decently flat from 30Hz to 20kHz, with a slight smile curve. If I had allowed myself more time, or revisit tuning, I think I could get them very flat.

Please note that these were not recorded in a perfectly ideal testing environment, some reflections may be present.

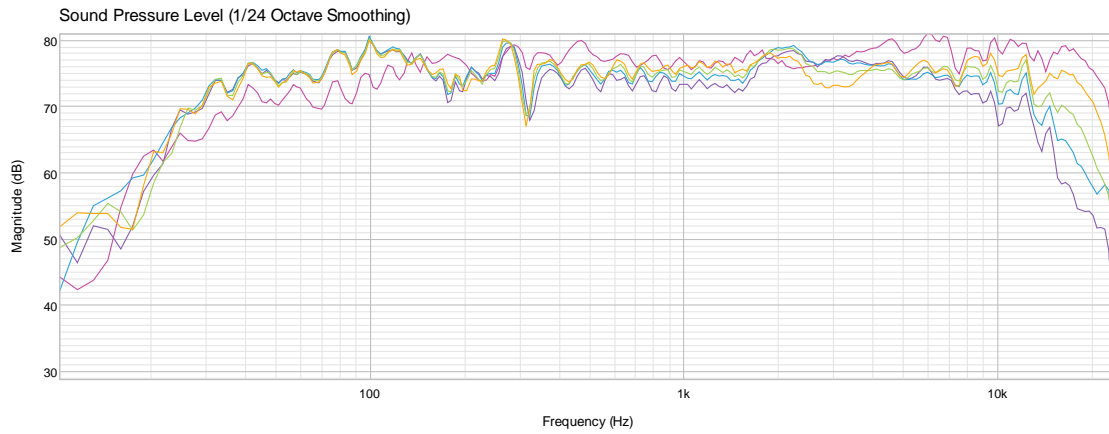
Frequency response:



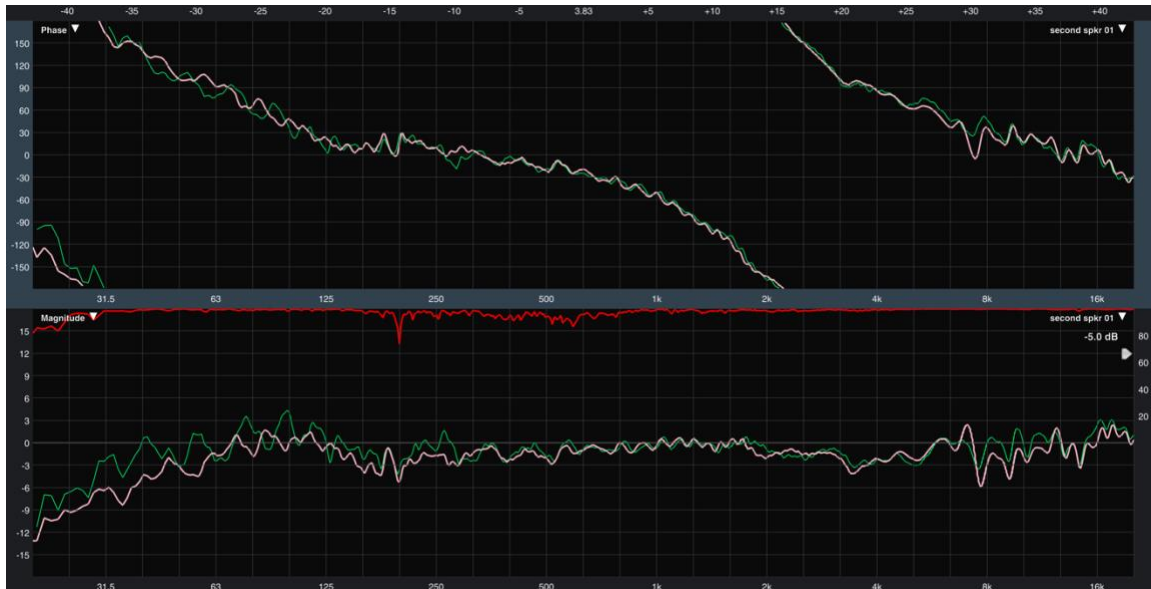
Harmonic Distortion



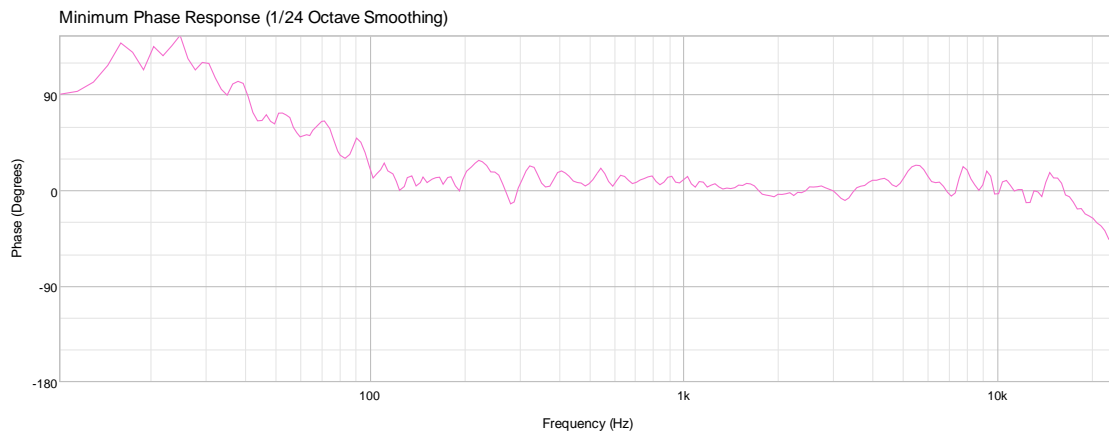
Horizontal Off Axis Response(15°,30°,45°,60°)



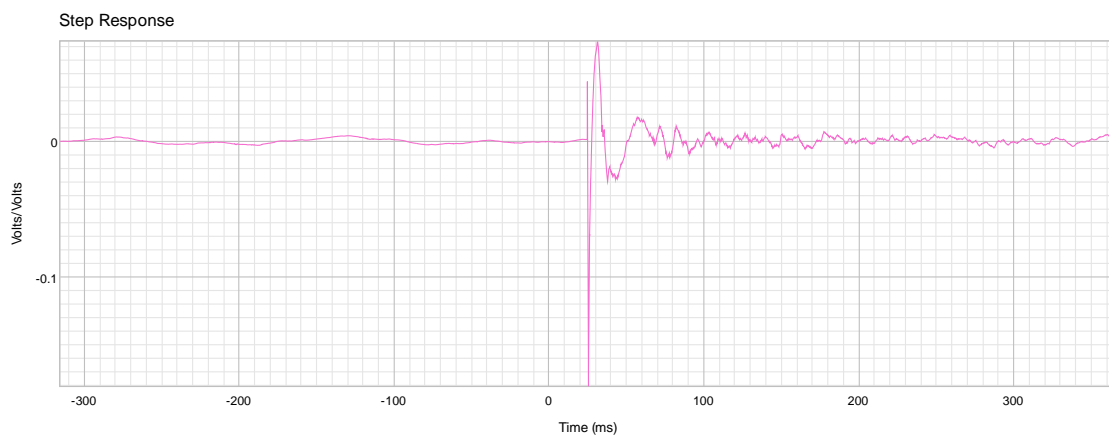
Left and right compared:



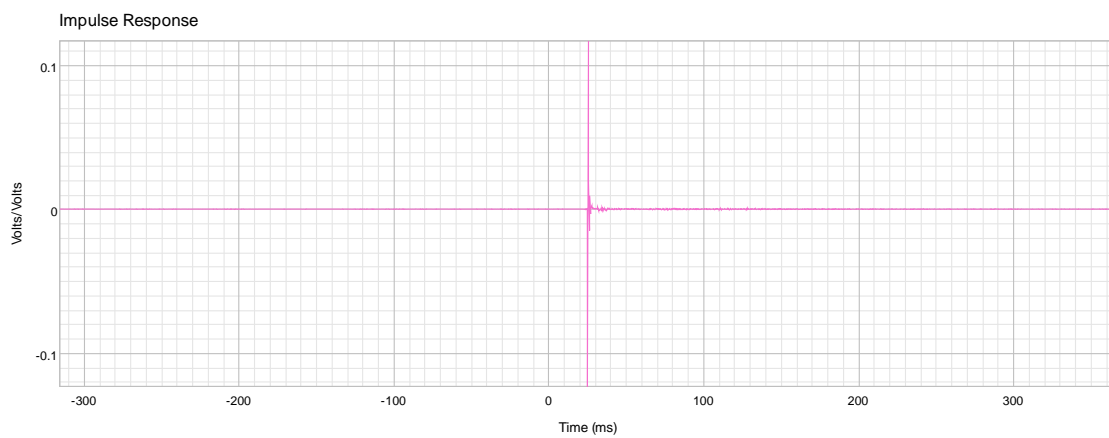
Minimum Phase:



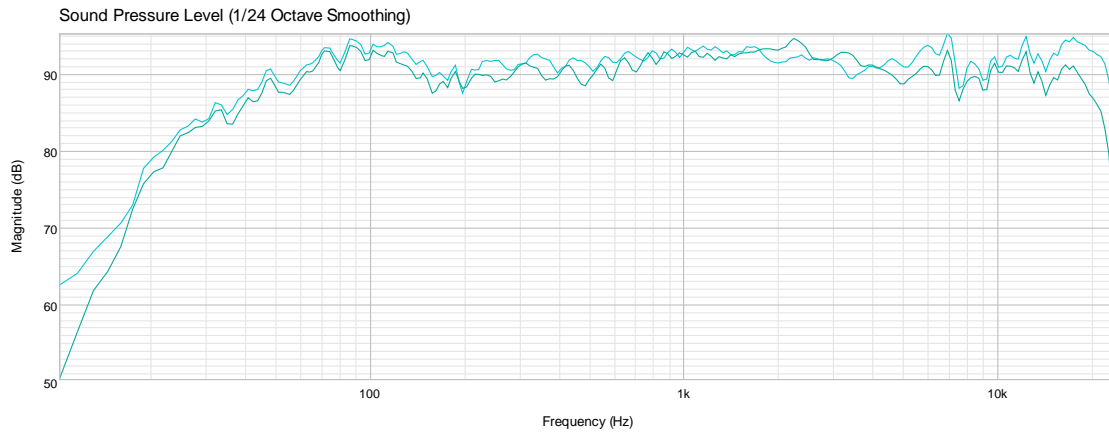
Step response:



Impulse Response:



Vertical off axis (30°)



**I also added this as an 'alternative listening axis', with a DSP preset that delays the tweeter to be in phase with the woofer at 30° above the midpoint of the two drivers, shown here:

