The JR149Plus: Upgrade to the Venerable JR149 Loudspeaker, Part 1 of 2

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The JR149 Loudspeaker is a variant on the Rogers LS3/5A theme. Utilizing a cylindrical aluminium enclosure, Jim Rogers' design departed from the LS3/5A in pursuit of low diffraction, and a funky modern look. By many accounts, the design was an equal competitor to the Rogers LS3/5A design. Utilizing variants of the same drivers (KEF B110 mid-woofer and T27 tweeter), the design sought greater bass extension using a larger cabinet. A detailed history of the speaker and resources are available at:
http://www.hifinews.co.uk/news/article/jim-rogers-jr149--vintage/9406
http://www.mcmullon.com/icollect/hi_fi/jim_rogers/jr_review.htm

Having lived with the JR149 during my early years, I always had a soft spot for its coherent delivery and delicate sense of space, especially when delivering smaller ensemble works. When the opportunity presented itself to work with a pair, I decided to bring these units back from the grave.

Where to Start

Any modification would best serve the original by enhancing what it did well, while minimizing its shortcomings.

The good:

- Excellent sense of depth and width: perhaps due to its inherent low diffraction, and definitely due to its small baffle, the JR149 could throw a convincing sense of space and depth, for a small point source design.
- Mid bass expressiveness: the B110's strong suit.
- Smooth mid-range, good integration with the tweeter.
- Good dispersion and multiple seat coverage.
- 70's funky looks that have aged well, an oxymoron if ever there was one.

The bad:

- Cabinet noise and interior resonances.
- Low sensitivity (81 to 83 dB depending which review you read).
- T27 perhaps a bit too delicate.
- Dynamic range limited, bass constricted.

The ugly:

- Poor B110 gets pushed too high, into some questionable break-up modes.

Design Direction

I attempted to modernize the sound as much as possible, without undue complexity or cost. Taking advantage of the unique cylindrical cabinet, I enhanced the benefits of low diffraction design by reducing reflections off the mid-woofer, and end caps. Felt was used to good effect.

Interior resonances were reduced by full packing with R12 fibreglass. Fibreglass is perhaps the most effective commonly available and low priced absorber for reducing interior reflections down into the mid bass.

I attempted to crossover as low as possible to avoid the woofer's erratic break-up, but in the end, the B110 won and insisted on being crossed higher than dictated by graphs and common sense. Throughout, the design targeted flat perceived response, neutral and natural

The Woofer Donors: KEF B110s

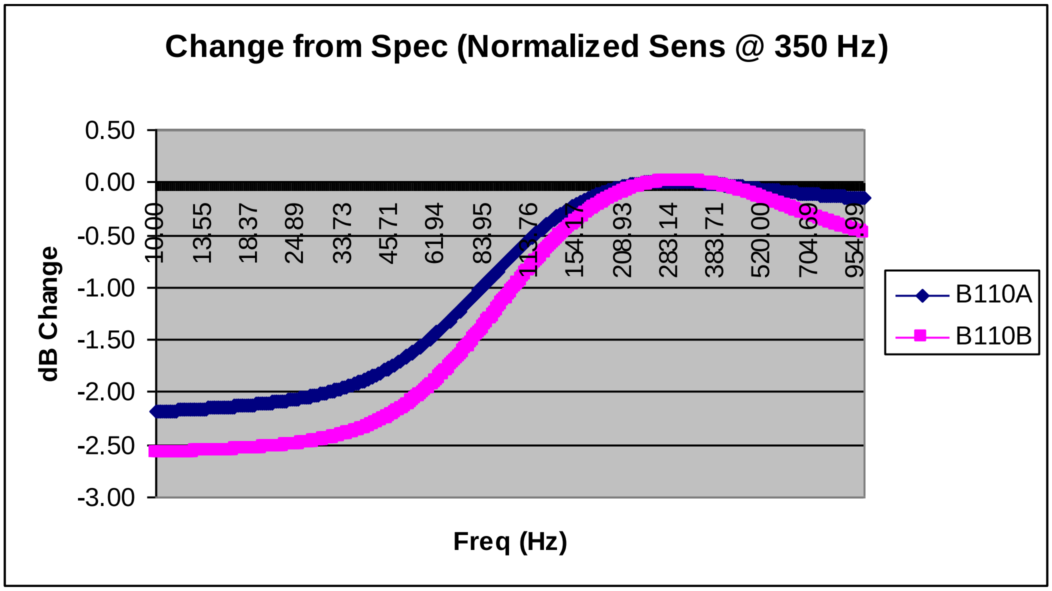
Many potential replacements for the B110 were considered, with the most promising being Monacor's SPH135/C carbon. The diaphragm is 2mm smaller, but the fixing positions are the same and it has a cast aluminium frame. The decision was made to maintain the B110 to keep life simple, and to retain some flavour of the original.

The Kef B110 Thiele Small parameters were measured directly after their long nap (estimated 10 years), then broken in and repeated. As the data shows, the compliance both before and after break in was approximately 1/2 the advertised value. Given that the Kef units had good quality control, and given that the spider usually dominates suspension stiffness, static ageing in this case appears to have caused a significant change in spider properties (varnish hardening?). The TS parameter story is shown below.

	Advertised	Prior to Break-In	After Break-In
Area (Sd) sq cm	92	92	92
Fs Hz	38 +/-2	50.228	50.027
Re Ohms[dc]	6.7 +/-0.2	6.817	6.738
Res Ohms		110.308	97.265
Qms	6.7	6.733	5.955
Qes	0.33	0.416	0.413
Qts	0.31	0.392	0.386
L1 mH	0.45	0.511	0.513
L2 mH		0.828	0.856
R2 Ohms		2.989	3.058
Vas liters	23.6	11.801	11.626

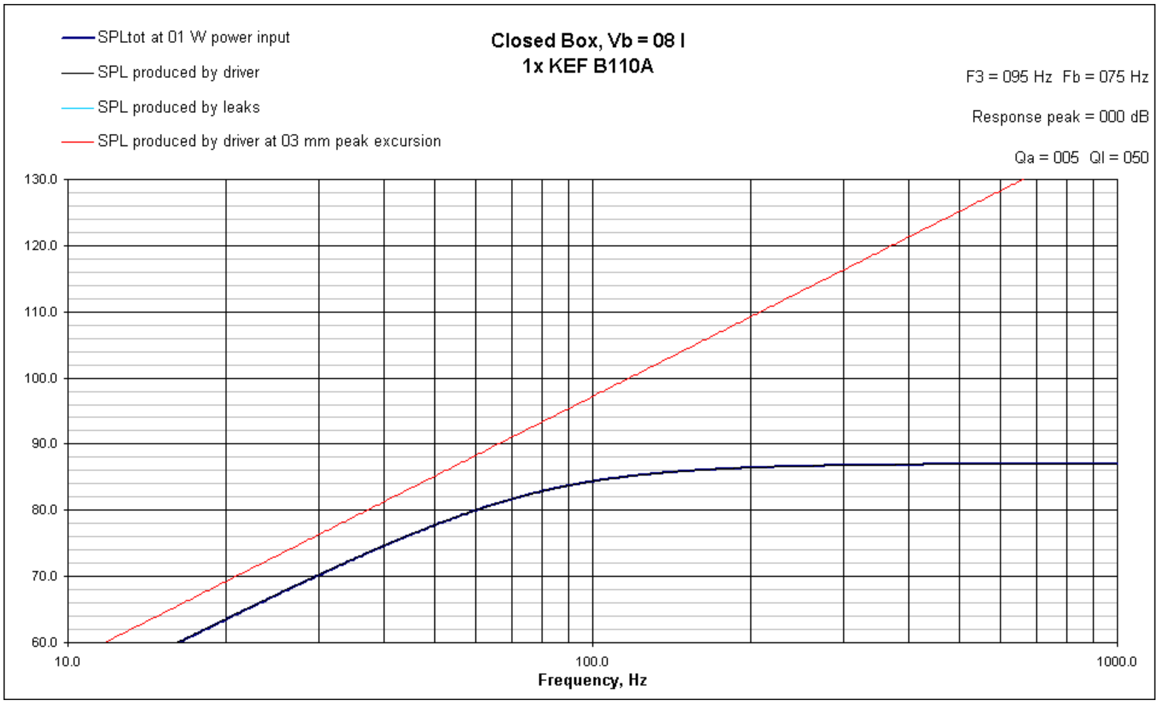
Mms(Sd) grams	10.114	10.349
Cms(Sd) uM/Newton	992.738	977.967
Bl(Sd) Tesla-M	7.231	7.289
SPLref dB	87.385	87.305

The ageing had a significant effect on the compliance, and it was non-recoverable. The impact in the JR149 enclosure was simulated with Unibox, for the left and right driver.



The impact was less than 1 dB above 83 Hz, and 2 dB at 61 Hz. Given the limited range of the B110 below 80 Hz, the impact wasn't a showstopper. In absolute terms, the variation is within the range of room placement variance, and the design parameters provided an over-damped response, per the intent of the original:

Physical Vb	**7.5l**
Absorption, Qa	**5**
Leakage, Ql	**50**
Alpha, a	**1.280**
Vb	**9.1l**
Fb	**75.35Hz**
F3	**94.62Hz**
Qtc	**0.577**
Response peak	**0.00dB**
Peak at	**none**

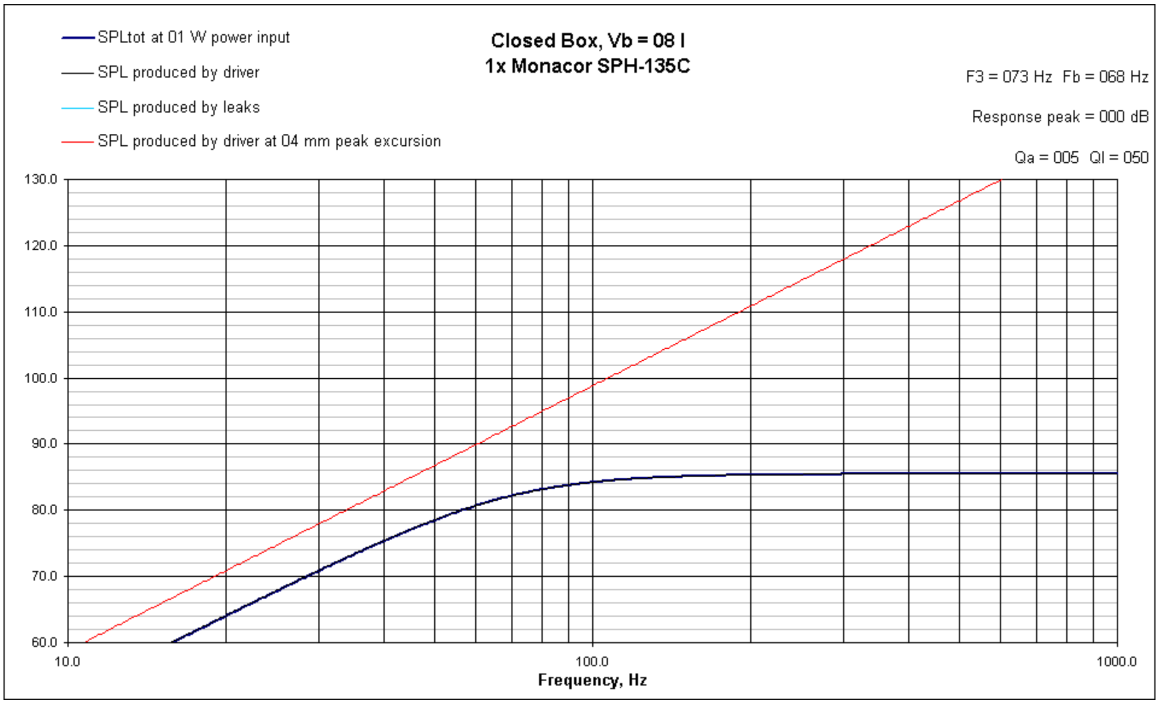


Note that the above curve is deceiving as it accounts for neither voice coil inductance, nor the high pass effect of diffraction as the cabinet changes its radiation from half-space to full space. This will be shown in measurements which will follow.

Near field measurements verified the response, with -3 dB @ 90 Hz, -6 dB @ 65Hz.

The Monacor is tempting, showing good low-end performance in the JR149 cabinet:

Physical Vb	**7.5l**
Absorption, Qa	**5**
Leakage, Ql	**50**
Alpha, a	**1.871**
Vb	**9.1l**
Fb	**67.64Hz**
F3	**73.11Hz**
Qtc	**0.656**
Response peak	**0.00dB**
Peak at	**none**



Scan-Speak D2905-9300

The low sensitivity and low power handling of the B110 allow ample margin for both tweeter choice and crossover point. The Scanspeak D2905-9300 was chosen. Its sweet but warm and laid back sound would complement the B110 well, while its good power handling and low fs allowed for margin in the crossover design, without the need for extensive impedance compensation.

The 9300s tend to deviate from neutrality above 10 kHz, where a generous but narrow peak (1/3 octave) enhances their sense of air. Admittedly the trump card was that they were available in my closet!

The Cabinet: a Strength and a Weakness

A weakness of the JR149 carried to the JR149Plus is the flimsiness of the aluminium enclosure. Even though it is internally lined with bitumen, wall vibrations are apparent, lending a small amount of upper bass bloom. For a small speaker such as the JR, this isn't entirely a problem as it fills in what can only be described as a weak low end, and the JR was traditionally known for its bass superiority over the LS3/5A.

An all-out modification would replace the fiber panel end caps with solid wood of at least ¾ inch thickness, and lining the cabinet with constrained layer damping. Both were considered beyond the scope of this upgrade.

The cabinet as delivered made use of a steel rod brace, installed by the previous owner: affixed to the rear of the enclosure, a U-shaped bent rod had its two end pieces terminate at the upper woofer mounting holes. The ends were then tapped to accept the two upper woofer mounting screws. This significantly increases baffle rigidity. The large metal faceplate of the Scan-speak 9300 also enhances the baffle. Plastic faced tweeters would not have offered this benefit.

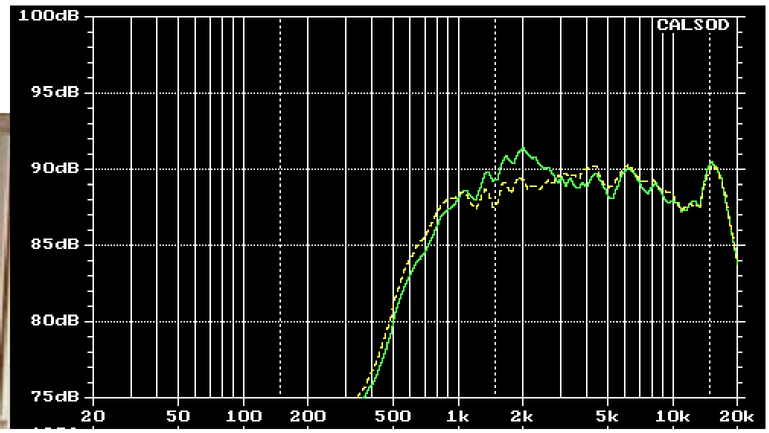
A front view of the JR149Plus, without top cap, front metal grill, or grille cloth, is shown on the right, compared to the original JR149.

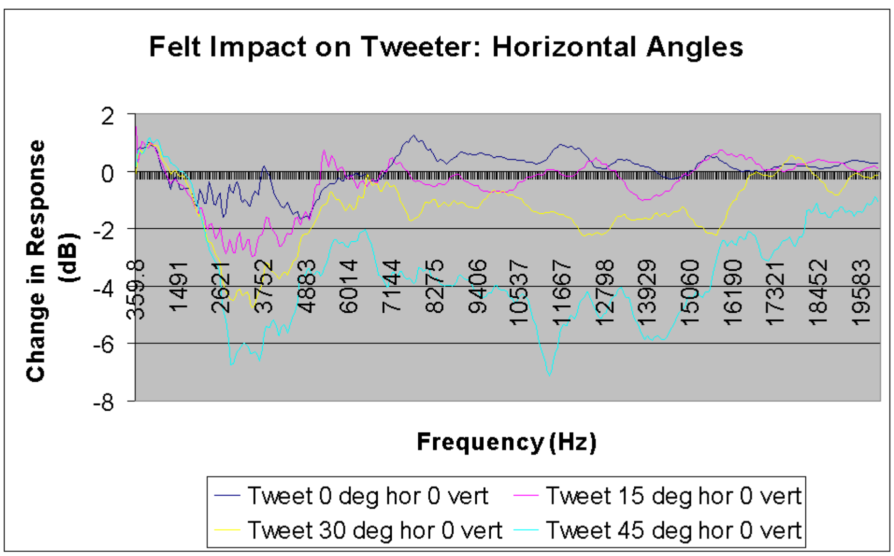
Felt was placed at the end caps and above the woofer to minimize unwanted reflections (which show up in JR's measurements for the original) that would harm the frequency response and the imaging. McMaster Carr F-13 Felt in 1/2" thickness was used. The strip between the woofer and tweeter was found through measurement to remove +/- 1 dB peaks and nulls on axis from approximately 2 kHz to 5 kHz, by reducing tweeter diffraction off the woofer cone.

The tweeter is mounted behind the baffle. This moves the tweeter back the thickness of the baffle and the tweeter's faceplate, allowing more options in the crossover design by better aligning the driver acoustic centers. It also moves the lobe upward, allowing the design to be optimized for both the seated position, and the standing position. The aluminium is quite thin and its thickness in front of the tweeter has no noticeable impact on the tweeter's response, or its sound. The tweeter was attached to the faceplate by drilling 4 small holes for the screws, then using stainless nuts and bolts held in place with lock washers. The holes are reversible if the design is ever taken back to its original state, as they are covered by the T27's large faceplate.

Aggressive diffraction control was also experimented with, placing a felt pad over the entire front baffle with a small square opening for the tweeter.

The felt is dense enough that it provided a weak horn loading to the tweeter at the expense of some off axis anomolies.   The general effect is shown below, on a diffferent speaker but using the D2905-9300





The felt made the speaker sound lifeless, so the full-felt treatment felt was abandoned.

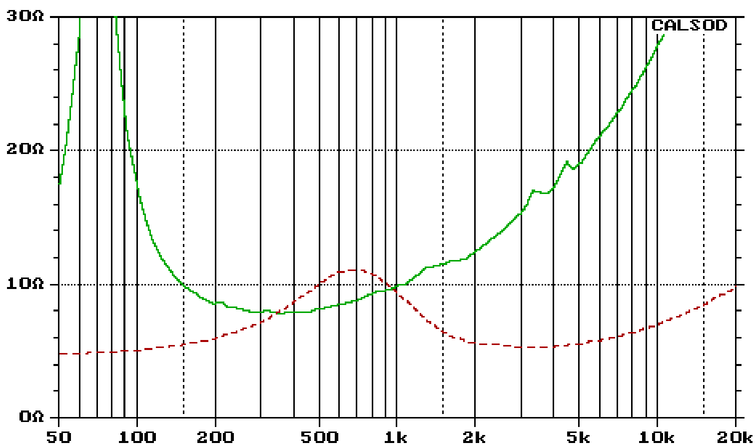
The grill cloth is kept off the drivers using a curved screen. In the JR149Plus, the screen is opened up using tin snips. If a replacement screen is needed, I've seen the same screen available at Home Depot, marketed as a type of gutter guard.

Crossover Challenges

The crossover is the heart of any speaker, and this one was a cruel mistress, being one of the most difficult crossovers I've ever wrestled with. The drivers had difficult limitations:

- Aggressive woofer breaks up between 3 kHz and 5 kHz.
- Low woofer sensitivity.
- Woofer/cabinet resonance induced bloom limiting the amount of BDC that was tolerable.
- Tweeter rise below 3 kHz in this cabinet, and above 10 kHz.
- Significant woofer and tweeter coil inductance.

It's also worth pointing out that the B110 resonances are truly aggressive, showing up in the electrical impedance as small spikes between 3 kHz and 5 kHz, of a magnitude I've never experienced with any other mid-bass driver.

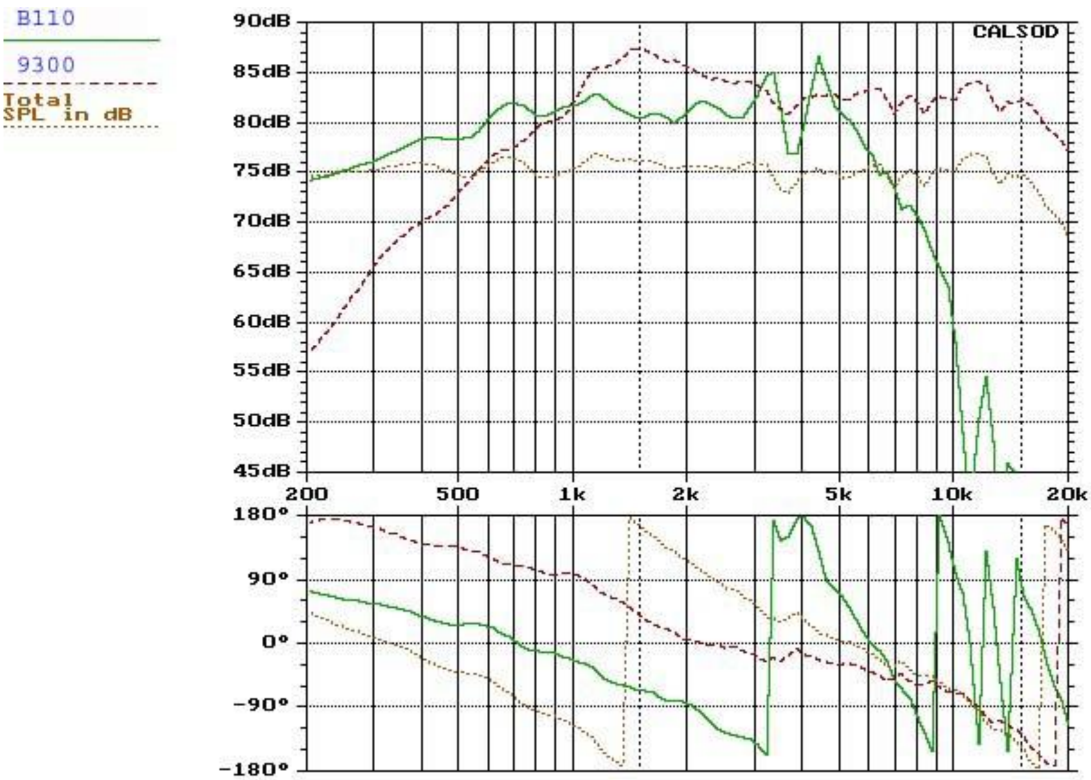


Measuring the Drivers

The drivers were first measured using the following set up. The floor padding significantly but not completely reduced the floor effect, which shows up in the measures as minor ripples from 300 to 800 Hz. The room boundaries limited the FFT window to a 200Hz lowest frequency, and rectangular windows were used throughout.

The following curve shows the driver responses in cabinet and the resultant on axis response. **Note that all sound pressure curves shown herein are 6 dB lower than real 1m/2.83V sensitivities**, but that all frequency responses are correct and the microphone, amplifier and measurement system were calibrated out of the measures. On axis is defined as the speakers on 24" stands, and the microphone position on a ray joining the lower edge of the tweeter, and a height of 42 inches, 8' away. The height corresponds to typical ear height in a listening chair, with a listening distance of 8'.

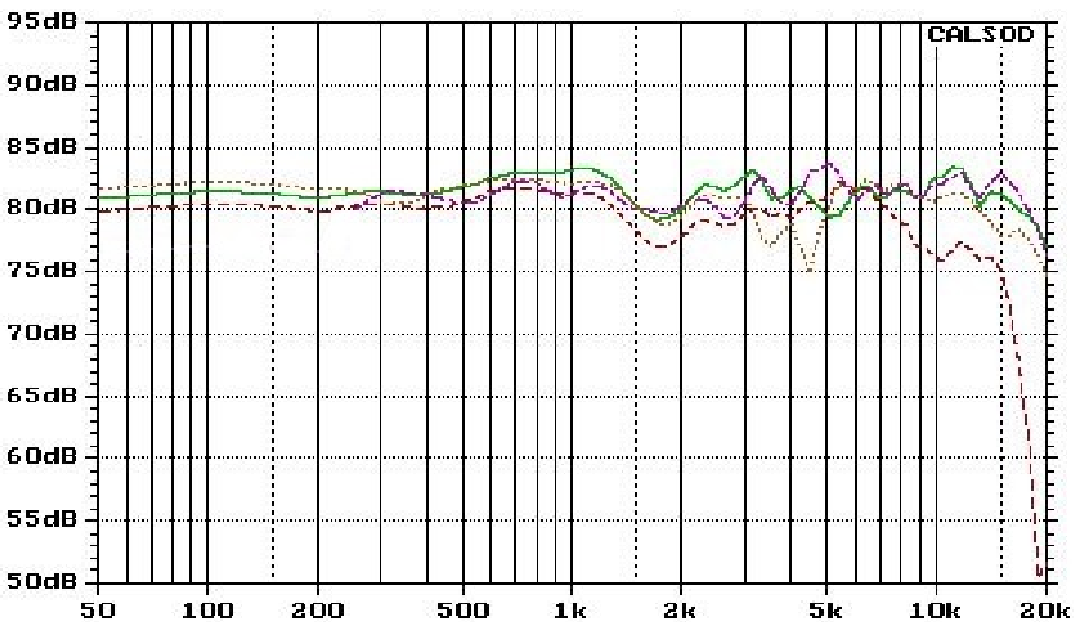
The woofer's upper end response would prove to be a challenge, and the first order of business was to manage it. Turns out that was much easier said than done and this woofer rejected rationale design choices that worked with many other drivers in the past.



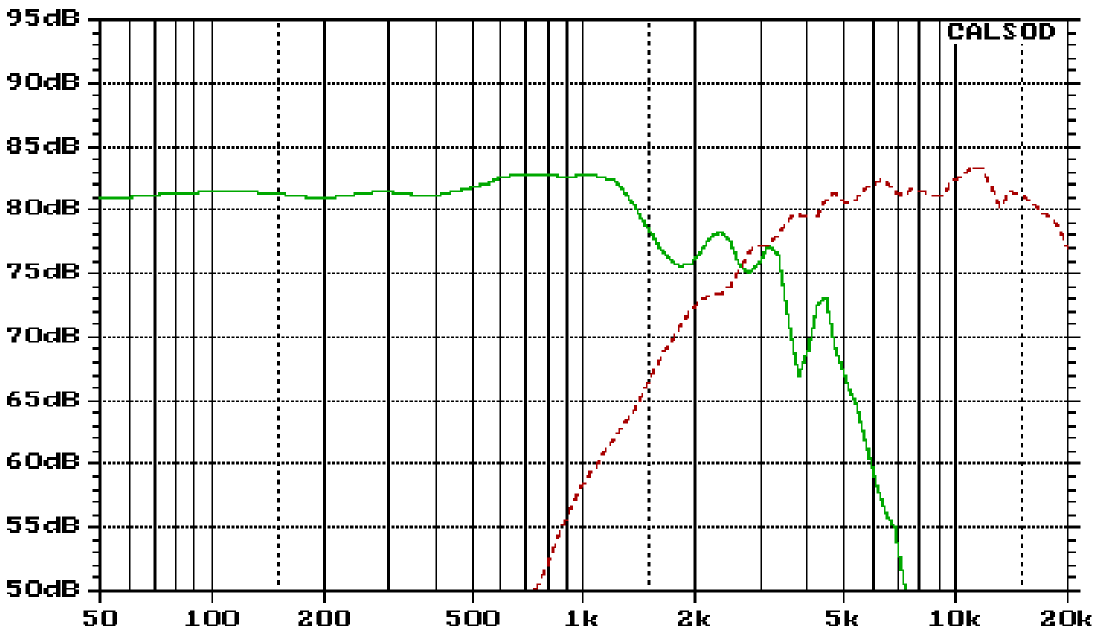
Ideally, these resonances would be suppressed by 25 dB or more, but it quickly became apparent that this would necessitate higher order filters. This wasn't pursued in order to minimize the filter order; my preference is to allow as much overlap as possible, within the constraints of the off axis response and driver power handling, as it is felt this better blends the tweeter's off axis dispersion through the crossover frequencies, with the woofer's.

The initial design (Appendix A, and beige summed curve above) looked great on paper and was lived with and tweaked over several years. It featured a woofer parallel trap to implement BDC and low pass inductance, and managed to bring the woofer resonance down 18 dB. Response was very flat (as good as +/- 1 dB 200 to 10,000 Hz) with nearly equally flat response to 30 degrees off axis. Unfortunately graphs can be deceiving and in pursuit of better neutrality without sacrificing musicality, various subtle variations were tried, adding a touch of "BBC dip", padding tweeter, tilting down the top end etc. In my room, none sounded quite neutral or natural. This design taught me flat isn't always right.

After several years of trial and error and perhaps a dozen crossover variants, a simpler 7 element crossover was chosen. This resulted in perceptually more neutral response in my room, but my room is quite reflective and the crossover in Appendix A may be favoured in larger or deader rooms. In the graph below, green is on-axis, red (high frequency rolling off) 30 degrees horizontally off axis, beige (dip at 4.5 kHz) is +10 degrees vertical (response while standing), and the last curve is -10 degrees vertical (response while sitting on floor).

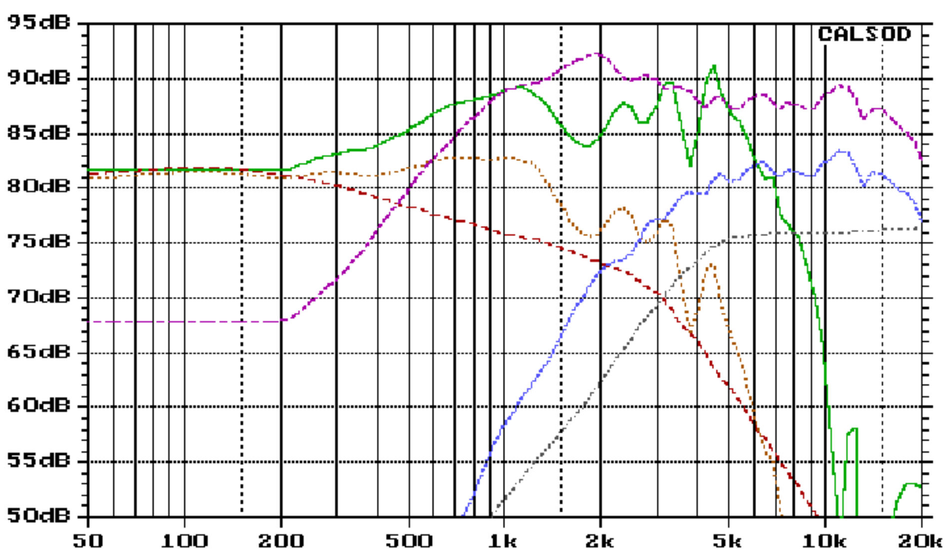


The crossover uses a broad overlap between woofer and tweeter but with tweeter high pass high enough in frequency to avoid tweeter distortion when pushed hard.

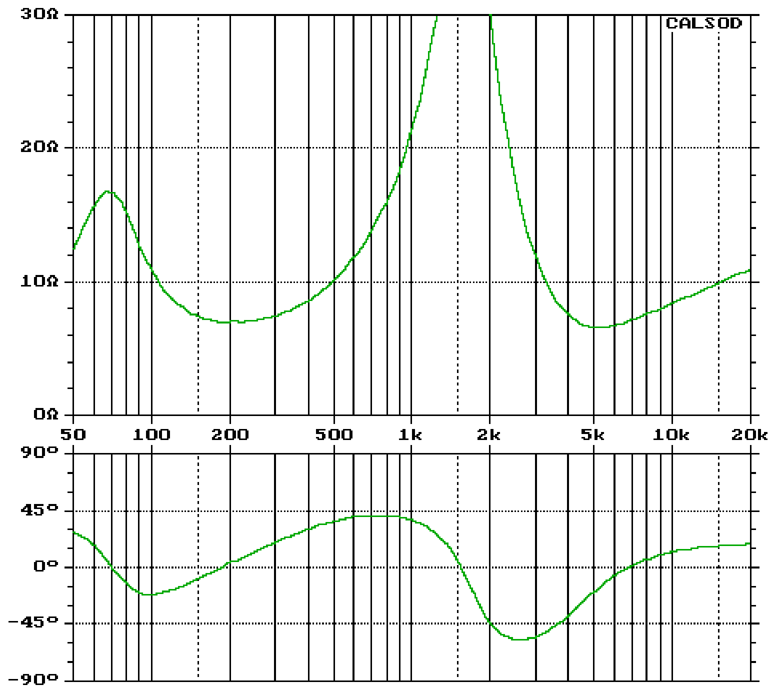


I never like operating a driver so heavily into break up, but after years of tweaking, this is what the B110 wanted. This exercise invalidated more than one of my design biases.

The crossover's high pass electrical response is -6 dB at 3 kHz, and the design implements at least 6 dB of baffle diffraction compensation. Ignore the responses below 200Hz, this was the lower limit of the files used in the simulation.



The impedance never dips below 6 ohms, but can become fairly capacitive through crossover.



Using a spice-like nodal naming convention, the crossover is below. The drivers are connected in positive polarity.

<u>Low Pass</u>

IND 2.00mH	1 2, 0.8 ohms dc resistance
CAP 6.10uF	2 0
RES 25.0 ohms	2 0

<u>High Pass</u>

CAP 4.0 uF	1 3
IND 0.40mH	3 0, 0.4 ohms dc resistance
RES 6.8 ohms	3 4
RES 15.0 ohms	4 0