The "Point75"

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Going three-way

The 2.5 clone project has been an extensive exercise, getting into a wide range of problems associated with loudspeaker building. Cabinet construction, cabinet tuning, crossover topology, quality of crossover parts, quality of drivers, tweaking drivers, balancing the drivers ("voicing"), speaker setup, room acoustics, just to name a few.

When this all started almost a year ago, I had no idea that it would develop into a whole lot of writing and reporting of measurements. And I had not anticipated the amount of response it would create. Unfortunately, only one person responded with (few) measurements. I'd very much hoped for this. First of all, to ensure measurements are reproducible, and further to exchange views on the interpretation of these measurements. Measurements are a tool to get some basics right, but it will not necessarily produce a good loudspeaker just by getting a flat response curve, a decent phase tracking, smooth cumulative response curves, etc. etc.

Clearly, measurements are necessary if you start from scratch with two drivers and an idea. And even with a clearly presented design we may be in serious trouble due to unexpected behaviour of the drivers. And the many hours spent on cabinets, crossovers, etc. can be wasted. Often I have bought "new" second-hand drivers from people who have given up a project because they have started up on textbook crossover formulas, and for sure this will never work. Drivers do not behave like ideal resistors, and if they did, the acoustic response would not be linear anyway.

The 2.5 clone project has seen suggested crossovers creating dips and bumps of up to 10 dB and some have been pleased with the performance without being able to hear that this was indeed very much LO-FI. Changing the inverted polarity of the 8513 tweeters has been suggested, which will produce a dip of 20-30 dB when you listen at certain positions. I have only heard of a few people who can draw a response curve from listening to a pair of speakers. I cannot. You have to be gifted to do that, and at the same time possess a lot of knowledge and experience in speaker building.

So where did it all end with the 2.5 clones? Well, with a few modifications we managed to get a better response curve and a more true presentation of a variety of musical sources. Start with the basic crossover, add a 3.3 Ohm resistor in series with the capacitor in the LP section, an 8.2 ohm tweeter series resistor and you will have a different speaker. The 2 kHz bump is gone, and the tweeter will stop shredding your ears on certain recordings.

Coating of the 8535 dust cap eliminates some cone break-ups, and the coating of the 8513 dome certainly transformed this tweeter into something that should have been done by Scan Speak in the first place. The 8513 tweeter was praised as the world's best 19 mm tweeter in the German magazine Hobby HI-FI 3/2001. I would have liked to see the HIQUPHON OWI tweeter included, which is derived from the 8512/13 drivers and thoroughly refined. That is to my ears. I cannot ignore the fact that the 8513 tweeter has been the chosen driver for a number of very well-recommended speaker systems for more than a decade. Some people have reported their concern regarding the quality of the tweeter, and others have said the unmodified tweeter is all they could ask for. I believe our sensitivity to distortion is very individual, as is our perception of sound in general.

Another aspect of this is driver matching. The carbon-filled paper cone of the 8535 drivers may not be the best choice for a bass/midrange that has to perform up to more than 3 kHz. Played at loud levels it can have a rough midrange presentation, and combined with a tweeter holding intrinsic deficiencies, we can end up with an unpleasant result. Matching the 8535 midbass with the coated 8513 tweeter or the 9500 tweeter raises the performance of the 8535 midrange. This was one of the lessons learned from this project. Drivers very much interact and it was well demonstrated here.

Comments from Darryl, Australia on the 2.5 clone sound:

I think we have here too quite different schools of thought on speaker design. Your efforts have produced a 2.5 clone that in my opinion more closely approaches neutrality. I'm not implying you've smoothed out much of the detail, but you have made this a "sit back and listen" speaker rather than one of the "wow! listen to that!" variety. When I first heard the clones, I remember thinking: "This sounds like a very high-quality Japanese 'tizz and boom' speaker." Unfair? Maybe, but my clones now

sound more like a Rogers BBC monitor - well, not quite - but I think that's the general direction you've taken them, and it's an approach I agree with. If some younger ears prefer the "wow" approach, so be it. I want to listen to music, not sonic shocks!
Darryl.

"Now we just need to get the midrange right!" Quote from a web discussion forum. Well, if we have to get the midrange right, we will probably have to choose another bass driver and this could compromise the bass performance, which is the prime quality of this design. It's no wonder the 2.5 clone has gained the apparent level of popularity judged from the numbers of papers published on the internet. It's based on a well-recommended design, cabinet construction is fairly simple and something that most people can cope with, only two drivers (cost), simple crossover (people with no experience in "electronics" can do this), the possibility of producing "the same thing" at a cost of approximately 1/5 of "the real thing" for sure is quite appealing[1]. Then at the end we are sitting in front these boxes, and there's nothing like connecting your own product for the first time and listening to your favourite music. We hear things from our vinyl/CDs we have never heard before because we will always hear things we have never heard before when we connect another pair of speakers, because they are different on a number of parameters. It may be more difficult to identify the (good) things we possibly do not hear any more…
To make a long story short, if the clones had a better midrange, these would be speakers that I could easily live with. If you want more you can always build a larger loudspeaker, but I cherish the modest size and the great bass, and I do not want to transform our living room into a "sound studio". So, the obvious way to go is to add a high-quality midrange driver and go three-way.

1.
If you buy 1,000 units of 8535 and 8515 drivers the cost of the drivers per pair would probably count for something between 100 and 200 US$. Add cabinets and crossover components and the total material cost for a pair of 2.5s could be in the range of 400 US$. To this we have to add production costs, shipment, marketing and retailer profit. Still, it makes no sense to charge 4,000 US$ for a pair of 2.5s here in Denmark.

The "Point75"

In the following I will present designs very much different from the 2.5 clone.
It was my initial intention to present two designs, a low-cost version, Point 75B, and a more expensive design, Point 75A. However, things have developed during the course of construction, thus two design are presented at almost similar cost and the follow-up to these constructions has gotten a new name, **Acapella**, which is presented in a new paper.

Point75A is based on the following drivers:
Bass: Scan Speak 18W/8535-00. Midrange: SEAS W15CY001. Treble: Expolinear NDRL 81 (~ATD, Le Ribbon)

Point75B uses same bass and midrange drivers, but a NEO3 PDR planar driver is substituted for the tweeter.
The NEO3 PDR presents a slightly softer treble compared to the NDRL but otherwise the designs are very much the same.

Please don't ask which one is the best!

Last, but not least, the midrange is going to work as a dipole in all versions, and the 75B for the tweeter as well.

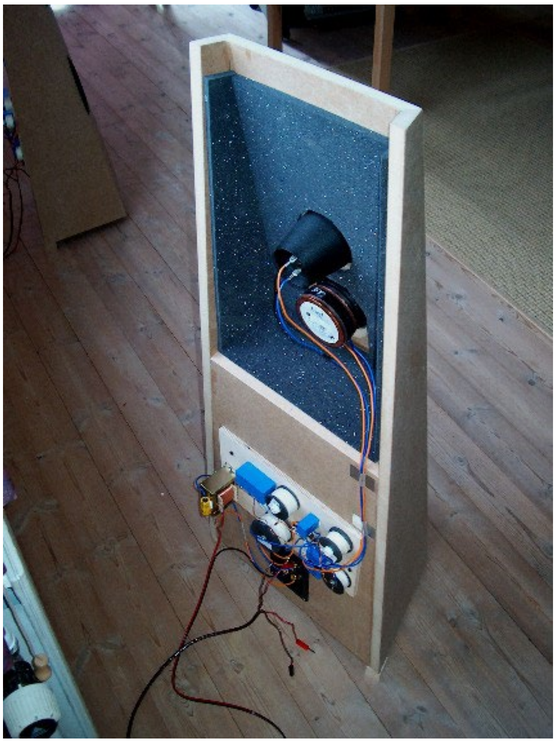


Fig. 1.
If you think this design is inspired by some commercially available designs, you are very much right. But this is not an attempt to make an exact copy of a well-known speaker. The

aim of this project is to produce a significantly better speaker.
I have auditioned the ProAc Future .5 and I wasn't impressed with the midrange coming from a small 4" paper cone.
So, let's forget about boxy clones and enter the world of dipoles, or a hybrid, a semi-dipole in this case.
These speakers have very much changed all my future plans for speaker building. I had a number of constructions on the drawing board, based on mostly vented designs, but these plans have become uninteresting working with the semi-dipoles concept.
Radical new design? Here's a picture from the book "Loudspeakers" by G.A. Briggs (Wharfedale), 1958.

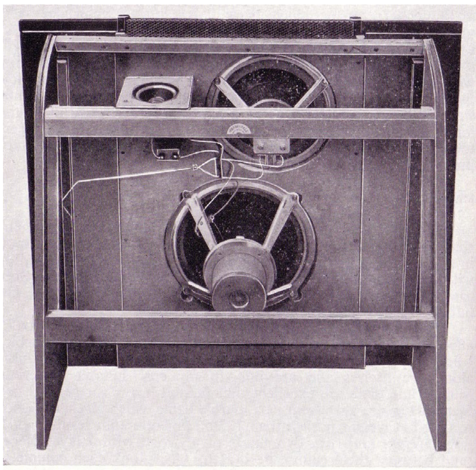


Fig. 2. All-dipole speaker with up-firing 3 inch "tweeter". This picture is from the fifties, so nothing new under the sun.

Check this web site:
http://oellerer.net/infinity_classics/Liste_Bilder/body_liste_bilder.html

Fig. 3. Infinity, Reference Standard II.
This one simply constructed by "sticking" a conventional bass cabinet through a curved front panel.

Infinity produced a large range of semi-dipoles in the eighties. Those few I heard were very impressive – and far beyond my economic reach.

Dipoles pop up from time to time and gain a new small audience. I believe convenience plays a major role here. Usually, dipoles require a rather wide front baffle, thus reducing WAF-factor considerably. You cannot place a dipole on the shelf or up against the wall, which is a must for the major part of speakers purchased.

I very much recommend visiting the web site of Siegfried Linkwitz at:
http://www.linkwitzlab.com/orion_challenge.htm
This site is an invaluable source of information on the question of dipoles and speakers in general. And there's a lot of reading!
Secondly, make a search for "dipoles" on the web. All varieties of dipoles can be found and the hybrid presented here is just one combination of a vented bass/dipole mid/conventional tweeter combination. Most work – to my knowledge – has been done on dipole bass constructions, which usually includes the use of very large bass drivers, electronic crossovers, equalisation and multiple amps. Dipole bass constructions are more susceptible to room placement, where the present suggested design can be placed much like your 2.5 clones.
That is 0.6-1.0 meter to the back wall.

Point75A&B: Cabinet construction

This is not going to be a thorough description of cabinet construction. Only a few comments and I'll let the pictures speak for themselves.

These cabinets are definitely not for beginners, and you will need access to a decent table saw or hand-held circular saw with a 48-teeth quality blade. Except for the front panel there are no parallel cuts in this construction. All other panels are going to be cut at odd angles and I suggest you make a test of one front panel + side panels. Once you have these glued in place, a lot of things become quite obvious, and it gives you a good feeling of size and appearance. Compared to the 2.5 clones, they appear quite smallish due to the pointy top.
The presented test cabs were made from 19 mm MDF, and the final cabs are intended

being made from a 20 mm laminate consisting of 10 mm hardwood glued to 10 mm MDF. This is my favourite material, as it gives you the possibility of sanding away irregularities, but it's a tedious task to make the laminate panels. If you use pre-veneered MDF, don't forget to order the side panels with the same veneer on both sides!

All details on panel cutting are given on pages 21-25.

The dimensions of the front and side panels are fairly accurate and once these are glued in place ensuring correct rear width at base and top, the rest is pretty much cut and try. The dimensions of bass enclosure panels should be taken with caution. Mark top panel attachment on front and side panels and check all dimensions and angles before cutting these panels.
The pictures do not necessarily follow order of construction.
As long as the front and side panel dimensions + the bass cab volume are correct, there's a lot of freedom in the design to follow your own practice of cabinet construction.

Fig. 4. Front and side panel assembly.

Fig. 5. Front and side panel assembly. Tape is used to keep panels in place.

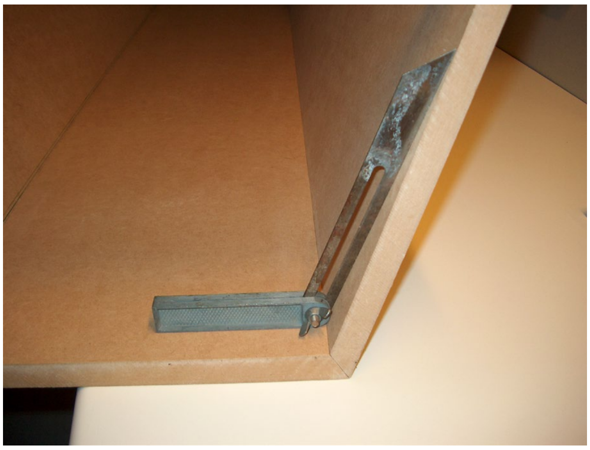


Fig. 6. IMPORTANT! Use a sliding bevel to ensure same angles of side panels to front panel.

Fig. 7. Gluing front and side panels. Check width at base and top for correct dimensions. These dimensions are very important for the further work. Keep panels in place with tape while drying.

Fig. 8. Gluing front and side panels.

Fig. 9. Bass enclosure bottom panel.

Fig. 10. Bass enclosure top panel.

Fig. 11. Bass enclosure back panel.

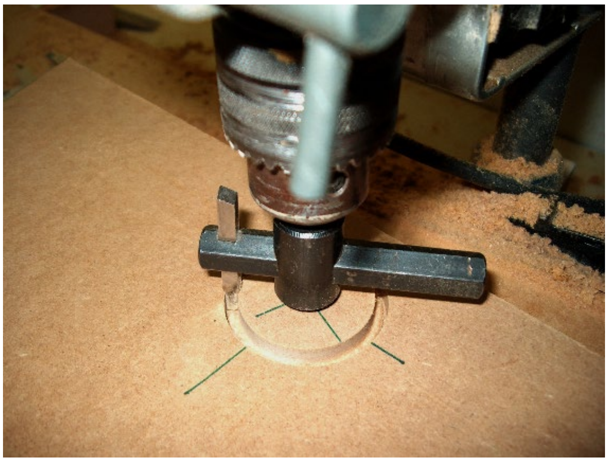


Fig. 12. Drilling hole for vent.

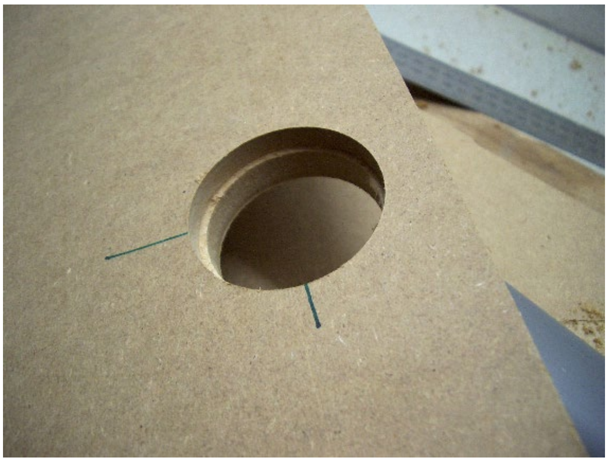


Fig. 13. Vent hole before flaring. Seen here from the inside.

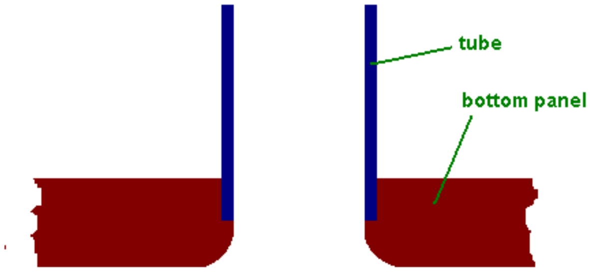


Fig. 14. Flaring vent.

Fig. 15. Vent with flared support.
Vent = 50 x 150 mm PVC pipe. Internal diameter = 45 mm. Center of vent hole from rear of bottom panel = 45 mm.
The vent support is attached by screws to the back panel of the bass enclosure.

Fig. 16. Bass enclosure assembly.

Fig. 17. Bass enclosure assembly.
My belt sander did a great job in smoothing things out after all panels were glued in place.

Fig. 18. Bass enclosure damping.
20 mm heavy polyester foam glued to all sides. No bracing was used in this test cab, but final cab will have a brace from front to back panel just under bass driver, approx. 5 cm wide.

Fig. 19. Midrange damping.
10 mm heavy polyester foam is glued to all sides. In the final cabinet two small angled MDF bars will be glued to side panels giving support for rear grille.
See sketch, fig. 20.

Fig. 20. Support for rear grille.

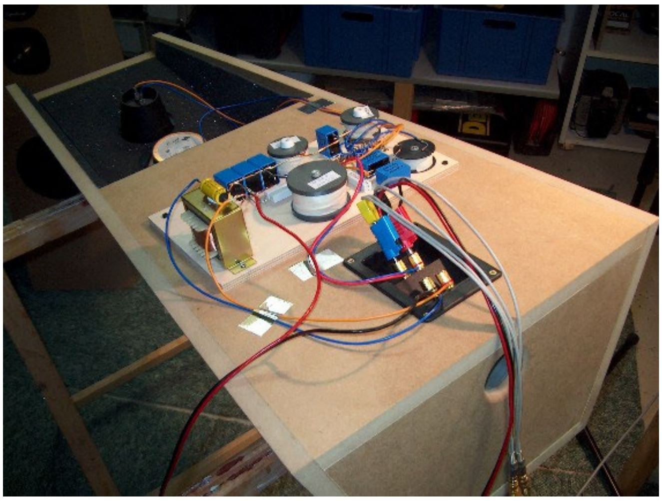


Fig. 21. Temporary crossover mounting.

Alternatively, the bottom panel can be attached by screws, and the crossover attached to the panel on the inside.
Use feet or spikes to lift the speaker approximately 3 cm above floor level to provide free air flow from the vent.
It is recommended that a pair of at least 40 cm wooden or metal bars are attached to the bottom for additional support. At high playing levels the slim cabinet is prone to rocking.
Don't do as these test cabs suggest. A firm base is a must.

Fig. 22, Point75, raw MDF test cabs.

More on panel cutting:

Since I constructed these test cabs I have tried to figure out an easier way to cut the panels, and from my "The Woodworker's Bible" I learned that an ordinary hand-held circular saw can do the job a lot easier and better than cutting free hand on a table saw.
These are the few tools needed to cut all panels:

Fig. 23.

A: A decent-size circular saw, here 185 mm blade. If you use pre-veneered MDF I recommend a 40-48 teeth saw blade to avoid ripping edges.
B: 2-3 clamps.
C: 30 x 50 cm 19 mm MDF for test cutting and determining distance from cut to straightedge.
D: 3 wooden bars to support panels to be cut.
E: 30 x 120 cm 12 mm MDF for straightedge. Have this one cut at your local MDF supplier to be absolutely straight.

Example:
With the circular saw seen on the picture, the distance – at a given cutting angle – from cut to straightedge has to be:
4^0 cut = 99 mm
11^0 cut = 98 mm
19^0 cut = 95 mm
35^0 cut = 90 mm

Fasten the straightedge to the 19 mm MDF test sheet and try cutting at all the angles needed and record the distances.

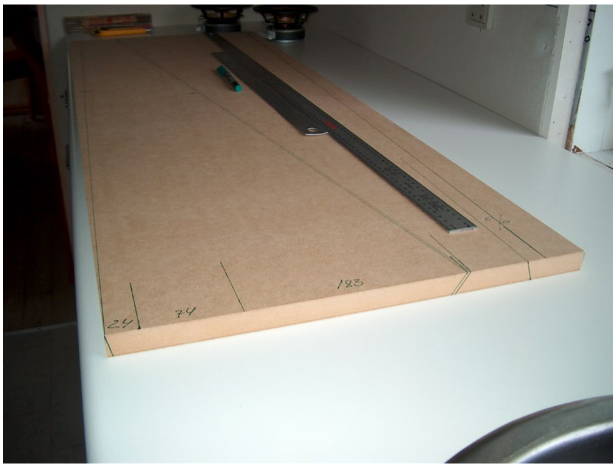


Fig. 24. Marking side panels (disregard numbers; this is a test cut for a larger cabinet).

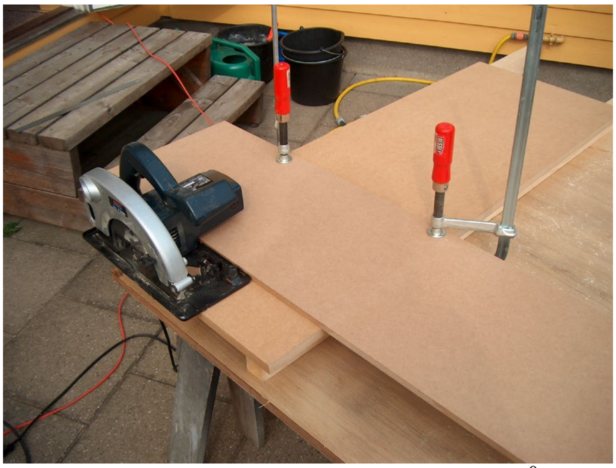


Fig. 25. Cutting bottom of front panel 11^0.

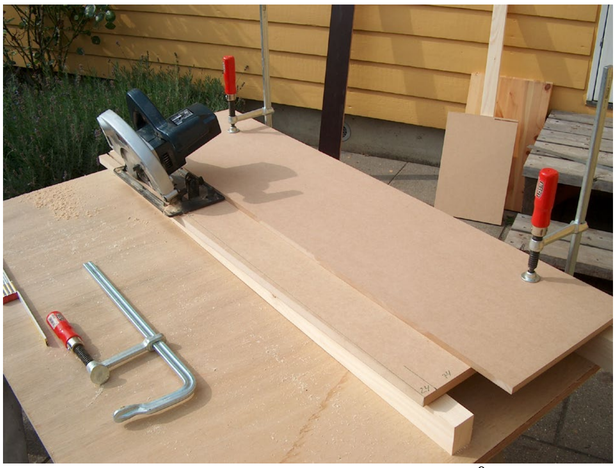


Fig. 26. Cutting rear of side panel 19^0.

With a fresh blade to the circular saw this provides nice clean cuts with no edge ripping and the possibility of using pre-veneered MDF.

Hope the pictures tell the story.
I strongly recommend doing a test cut on the side panels and front panel. I did use quite some MDF sheets before I got a good sense of the shape of these panels.

Drivers:

Bass driver, Point75A&B:

Fig. 27. Scan Speak 18W/8535-00.

Midrange driver, Point75A&B:

Fig. 28. SEAS W15CY001, coated magnesium cone.

Tweeter, Point75A:

Fig. 29. Expolinear NDRL 81.

The Expolinear NDRL is marketed by the company Expolinear, http://www.expolinear.de/, Germany and can be purchased from http://www.lautsprecher-shop.de/hifi/. It has been more than difficult to source the origin of these drivers, but possibly they are produced in Hungary. They can be found with different sensitivity and face plates. Alternatively, the ATD "LeRibbon" can be used. The ATD "LeRibbon" is manufactured by the Italian company ATD, Milan, and to my knowledge only produced in a 4 ohms version. Expolinear strongly denies any relationship to the ATD drivers, but I feel certain that one of these drivers is a copy of the other.

Both drivers are fitted with neodymium magnets and an approximate 91 dB sensitivity. A crossover for the ATD driver is suggested, but I cannot guarantee for the results.

Fig. 30. ATD LeRibbon.

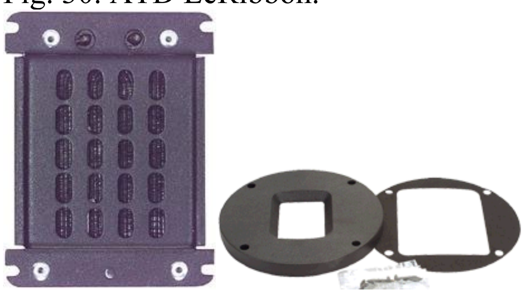


Fig. 30a. NEO3PDR and faceplates.

The “Point75A” crossover, version 12:

Drivers:
18W/8535+W15CY001+NDRL81

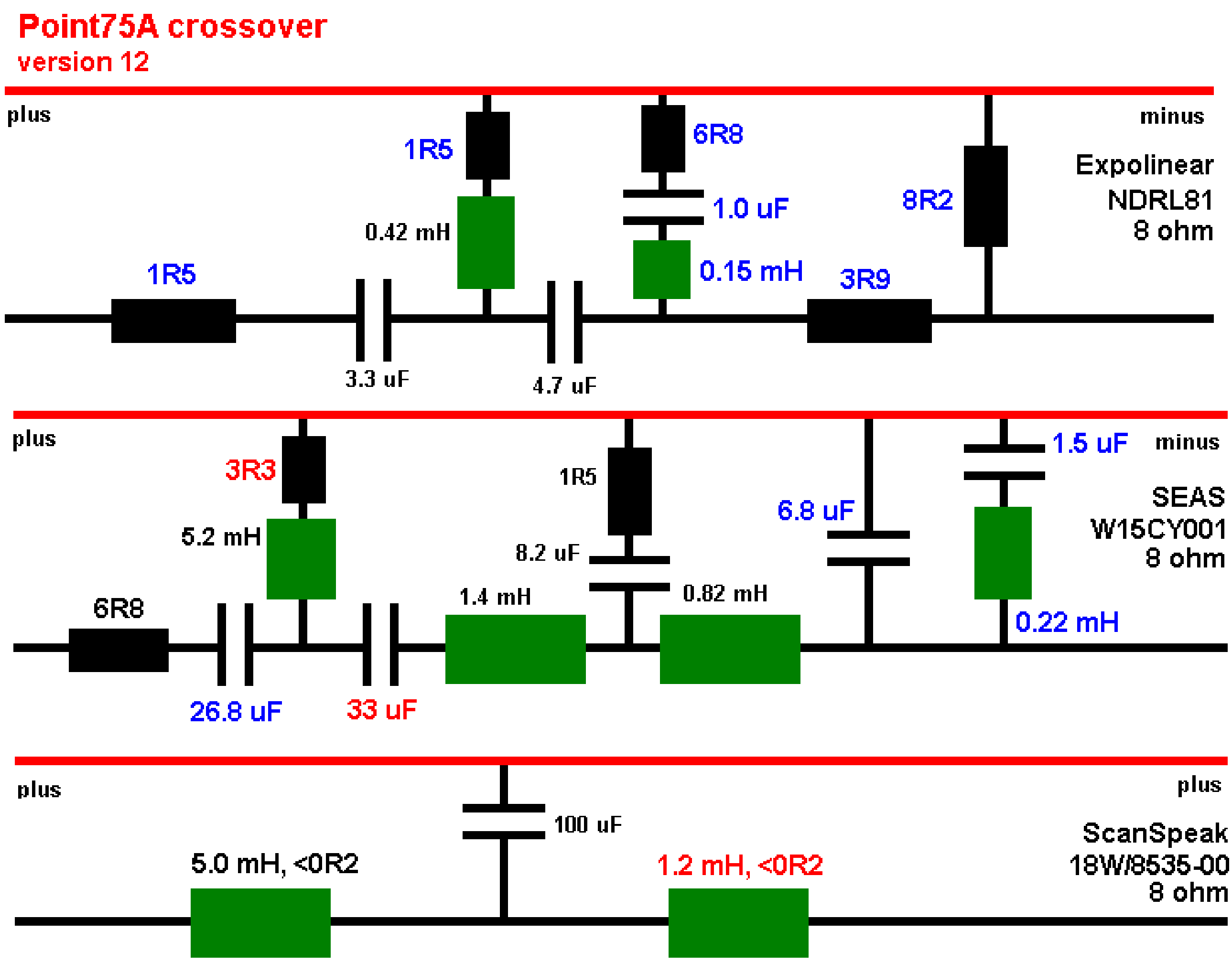
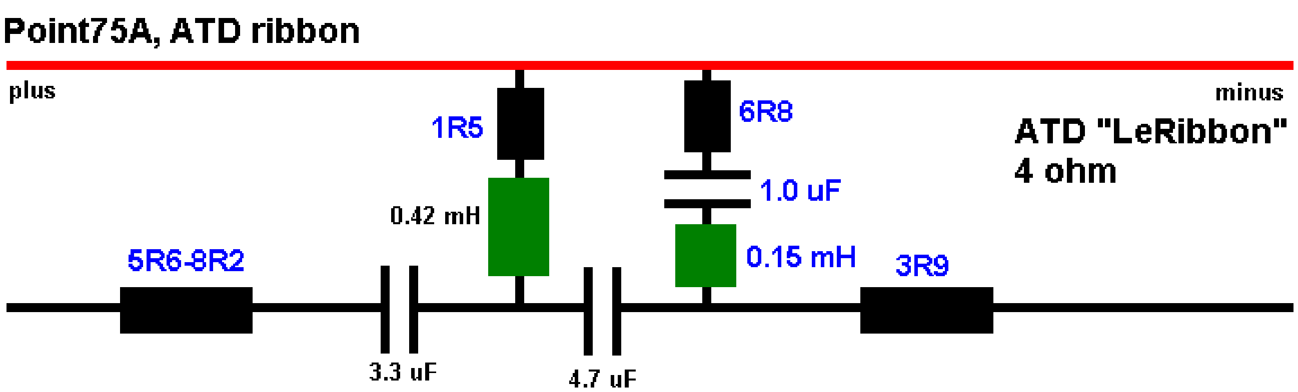


Fig. 31.



Recommended crossover parts, Point75A:

Resistors
Use low inductance resistors, film or metal oxide. All are 5 W except 6R8 to mid driver = 10W.
Capacitors
Polypropylene capacitors are recommended except for 100 uF electrolytic in bass LP section.
Coils
5.0 mH trafo for bass section, < 0R2 (5.6 mH trafo unwound to 5.0 mH)
5.2 mH, 0.65 ohm, use 0.95 mm wire coil (5.6 mH cored coil unwound to 5.2 mH)
1.4 mH, <0R2, use cored/un-cored 1.4 mm wire coil (1.5 mH cored coil unwound to 1.4 mH)
0.82 mH, <0R2, use cored/un-cored 1.4 mm wire coil
0.42 mH, < 0R2, use un-cored 1 mm wire coil (0.47 air cored coil unwound to 0.42 mH)
0.15 mH, < 0R4, use air cored 0.8 mm wire coil

P75A v12 crossover components from:
http://www.lautsprecher-shop.de/

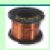
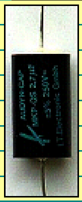
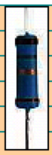
target value	actual value	wire dia. mm	ohm	item no.	number	€/ea	€, total
5.0 mH 	5.6 mH	1.40	0.15	Mo 125460	2	13.80	27.60
5.2 mH 	5.6 mH	0.95	0.51	I-0193	2	6.10	12.20
1.40 mH 	1.5 mH	1.40	0.34	I-0062	2	7.70	15.40
0.82 mH	0.82 mH	1.40	0.26	I-0057	2	6.10	12.20
0.42 mH 	0.47 mH	1.40	0.19	I-0054	2	4.00	8.00
0.15 mH	0.15 mH	0.90	0.21	I-0604	2	2.80	5.60
0.22 mH	0.22 mH	0.90	0.26	I-0608	2	3.00	6.00
Coils in red: unwind to target values		application	properties				
100 uF 	100 uF	bass	electrolytic	I-1085	2	4.30	8.60
33 uF 	33 uF	mid	polypropylene	I-1410	2	12.30	24.60
10 uF	10 uF	mid	polypropylene	I-1380	4	5.10	20.40
8.2 uF	8.2 uF	mid	polypropylene	I-1370	2	4.30	8.60
6.8 uF	6.8 uF	mid	polypropylene	I-1360	2	3.60	7.20
4.7 uF	4.7 uF	tweeter	polypropylene	I-1340	2	3.10	6.20
3.3 uF	3.3 uF	tweeter	polypropylene	I-1330	2	2.60	5.20
1.5 uF	1.5 uF	tweeter LCR	polypropylene	I-1310	4	2.00	8.00
1.0 uF	1.0 uF	mid notch filter	polypropylene	I-1300	2	1.70	3.40
8R2 	8R2		MOX	I-1942	2	0.50	1.00
6R8	6R8		MOX	I-1980	2	1.10	2.20
6R8	6R8		MOX		2	0.50	1.00
3R3	3R3		MOX	I-1932	2	0.50	1.00
3R9	3R9		MOX	I-1934	2	0.50	1.00
1R5	1R5		MOX	I-1924	6	0.50	3.00
						total €	188.40
ScanSpeak 18W/8535-00				-	2	163.00	326.00
SEAS W15CY001				I-6768	2	189.00	378.00
ExpolinearNDRL81				E-NDRL-81	2	147.00	294.00
total, drivers							998.00
total drivers + CO						total €	1,186
						US$	1412

Fig. 33. Crossover part from http://www.lautsprecher-shop.de/

Point75A, sound

So, what's the sonic impact of a having a wide baffle and a dipole midrange?

I have held to the argument that a narrow baffle would diminish the degree of early reflections, thus enhancing the perceived depth and transparency.
Having worked on a Virgo II "clone" (three-way speaker with side-mounted bass drivers) and a very narrow front baffle, I could accomplish a very good presentation of depth, and the side-mounted bass drivers only working with 6dB roll-off, were probably part of this quality. I assume that side-mounted bass drivers working up to 1000 Hz have some of the same qualities as a dipole bass arrangement. In fact the Virgos are bi-poles, projecting to the sides in-phase contrary to front/back like normal bi-poles would do. I never managed to get the bass/mid integration right. I guess the bass/midrange 6 dB crossover causes some phasiness in the upper bass/lower midrange and this adds to a somewhat artificial sense of depth in the soundstage.
Setting up a speaker with a conventional bass + dipole midrange was quite a surprise in terms of depth and transparency. It is quite remarkable how these speakers uncover the quality of your recordings. Acoustics, poor and good microphone setup, sibilance, etc., etc. You can hear from track to track singers' different distance to microphone and changes of studio acoustics, natural or electronically. It's got an electrostatic quality and listening to the 2.5 clones aside the Point75 makes you realise the significance of the term "boxy" sound.

Linkwitz:
When a speaker driver is mounted in a box it radiates as much energy into the space in front of the cone as it does into the much smaller space behind the cone. What happens to the air borne energy inside? At long wavelengths it is common practice to store it in resonant structures to extend the steady-state low frequency response of the speaker. In general, the energy leads to very high sound pressures inside the box. A small amount of the energy is lost as heat in the stuffing material, some in the process of flexing the cabinet walls. Much of it reappears outside the box, because the thin cone presents a weak sound barrier. Just how much is difficult to measure, but it is a contributor to the frequency response.

The bass from the "Point75" is slightly leaner compared to the 2.5 clone and suits my listening room better. But don't expect (or fear) a much different bass performance. The 8535s are still doing a great job and the floor-mounted vent makes the speakers less susceptible to room placement.
Here's the predicted response in my listening room:

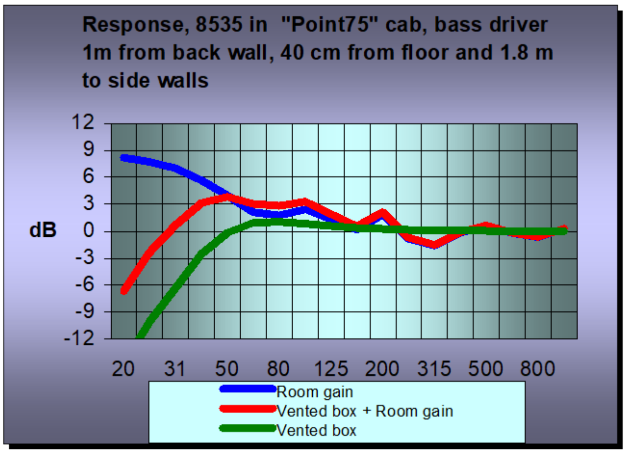


Fig. 34. Predicted room response.

It's difficult to compare the midrange of the 2.5 clones and the Point75. They are very much different.
The first thing you observe with the Point75 is that you tend to play louder. This is an almost certain sign of less distortion. And the beaming nature of the 2.5's upper midrange at high level is gone for a wider and deeper soundstage.
With the W15CY001 mid-driver you can play at very low level and still have a remarkable level of transparency.
A number of 4 inch midrange drivers have been tested: SEAS W11CY001, Vifa PL11WH-00-08, ETON 4-300 and one 5 inch driver, SEAS T14RCY-P-H. None of the 4 inch drivers had sufficient membrane area to cope with playing at higher levels. They start "yelling" or "honking". I asked Linkwitz about this problem:

The "yelling" of your small drivers is due to nonlinear distortion, basically due to insufficient linear volume displacement capability. It is not a function of electrical or mechanical damping, but due to drivers of too small size for a dipole.
Siegfried Linkwitz.

The T14RCY/P-H wasn't that bad, but it couldn't beat the SEAS W15CY magnesium

driver when it came to transparency. The new SEAS M15 CH-001 was also considered, but is quite expensive and has higher distortion compared to the W15CY001. But I'd love to try this driver with the small neodymium magnets and very low cone weight.
Balancing the speaker's treble level is quite critical (as always) and it is necessary to listen to a wide range of recordings and preferably test CDs to get it right. With the ribbon tweeter you will learn to love sibilance (!), that is when it's not excessive.

With the NDRL81 tweeter I suggest you try 0R, 1R5 or 2R2. I have found 1R5 to the NDRL driver gives good mid/tweeter integration. This driven by a solid state amplifier. Valves may perform different and it is recommended you do this fine-tuning carefully.

Measurements

As said earlier, measurements are necessary to get some basic properties right.
Though much of the basic crossover design was available from the start, the implementation of the midrange and tweeter drivers called for proper attenuation to reach an acceptable frequency response, and this was done by numerous MLS response readings and listening tests. Still, I favour the "BBC dip" response curve (the "BBC dip" prescribes a 2 dB sloped attenuation from 100-10,000 Hz).
This is definitely not an easy target if you don't happen to have a reasonably sized anechoic chamber in the back yard. With any PC-based measuring system used in a normal living environment you can normally only measure the frequency response down to 300 Hz due to reflections. Measuring at 1 meter distance, it takes the sound 2.9 ms to reach the microphone (100/34000 = 2.9ms) and if the driver and microphone are placed 0.8 m above floor level at 1 meter distance, the earliest reflection from the floor will reach the microphone 2.6 ms later. So, you're lucky if you have a reflection-free window of 3 ms. Thus the lowest reliable frequency is determined as 1/(0.0055-0.0029) = 385 Hz.
On a very quiet summer's evening I take the speaker to the garden, place it high on a table + place some acoustic absorbent on the lawn and I can have a measuring window of 20-30 ms giving frequency readings down to 50 Hz. I still have to do this on the Point75.
An easier way to get a picture of the low-end performance is doing 1/3 or 1/6 octave FFT measurements in the listening room. But as can be seen in the 2.5 paper, this can be quite confusing as moving the speaker around can make large variations.
All this to explain why few measurements are shown below 300-400 Hz.

Measuring the frequency response of a dipole speaker is a new challenge compared to any closed or vented design.
With an open baffle the response is prone to back-wave cancellation, giving irregularities in the midrange response.
More on this later.

Impedance, Point75

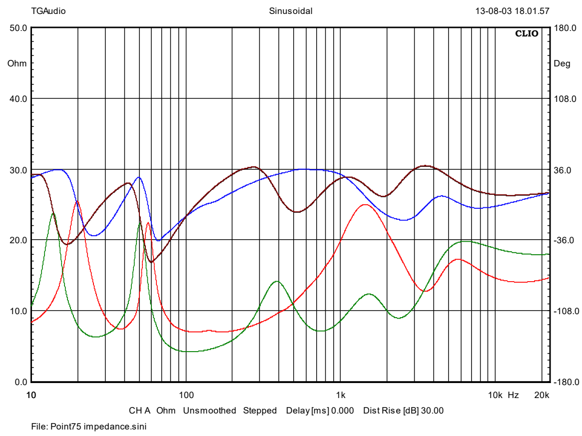


Fig. 35. Impedance curve of Point75A (green = impedance, brown = phase) and the 2.5 clone (red = impedance, blue= phase).
As can be seen the bass cabinet tuning is much lower (28 Hz) compared to the 2.5 clone (38 Hz).
The Point75A is an easier load to your amplifier than the 2.5 clone. My amp runs less hot when driving the Point75A&B.

Crossover frequencies

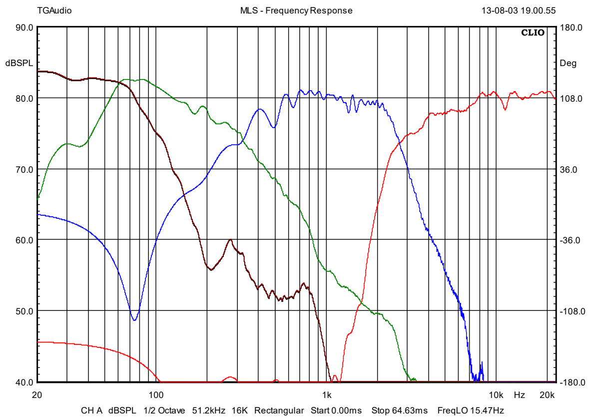


Fig. 36. Near field response of drivers + port. Points of crossover = 300 Hz (B-M) and 2.8 kHz (M-T).
Note very smooth roll-off characteristic of midrange driver. First sign of cone break-up at 8 kHz is 40 dB down.

Targeting the "BBC-dip" frequency response curve

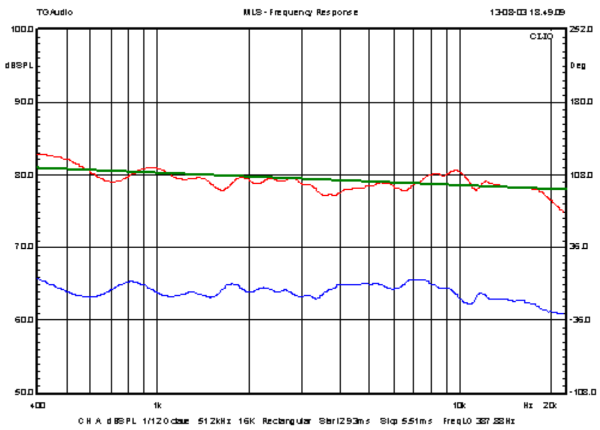


Fig. 37. BBC-dip. Adding a straight line through the response graph shows a frequency response of approx. +/- 2 dB from target.
Blue = minimum phase.

Lateral dispersion

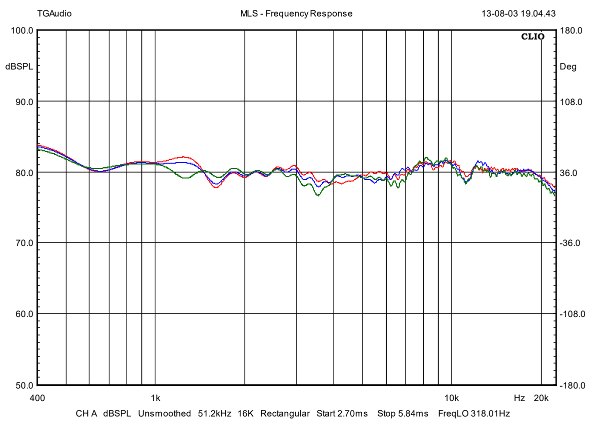


Fig. 38.

Frequency response measured at 1 meter distance at tweeter height. 0^0 = red, 10^0 = blue and 20^0 green.
In order to obtain reliable results, most response curves presented here are averages of 3 measurements at 0, 10 and 20^0.

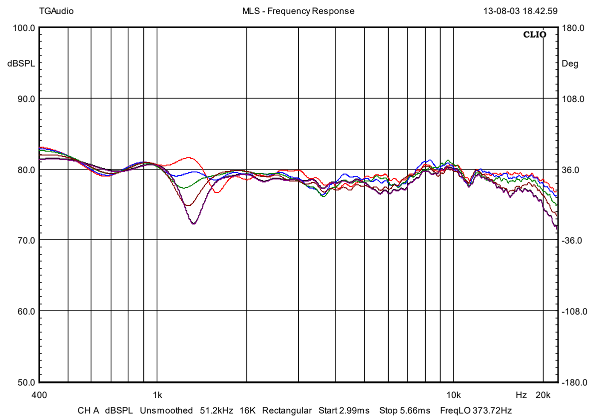


Fig. 39.
Lateral dispersion at 0^0 (red), 20^0 (blue), 30^0 (green), 40^0 (brown) and 50^0 (purple).
As can be seen the lateral dispersion of the construction is quite exceptional. Very few tweeters have this capability.
The irregularities seen at 1.5 kHz are due to back-wave cancellation and become more pronounced when measuring at large angles. At 10-20^0 the response is almost flat in this region.
In principle there's no such thing as edge diffraction from dipoles due to the energy projected from either side being out of phase. And in theory there should be no sound at all listening at a 90^0 angle! But we're not listening in outer space or a 100% anechoic chamber. We are surrounded by walls, which will reflect the sound radiated to the front and to the rear.

Vertical dispersion

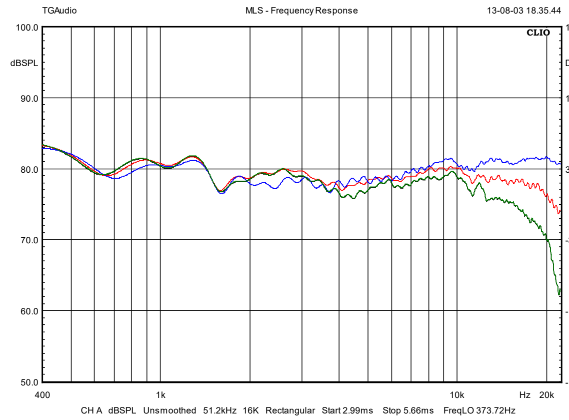


Fig. 40. Point75A, vertical dispersion, 1 meter distance.
Blue = 10 cm above tweeter height, red = between tweeter and midrange, green = 10 cm below midrange height.
As for most ribbon tweeters the vertical dispersion is low.
Usual the combination of wide lateral dispersion and narrow vertical dispersion is associated with good depth perception as reflections from floor and ceiling are considered detrimental to this quality.
It's difficult to achieve this picture with conventional dome tweeters.

Cumulative spectral decay

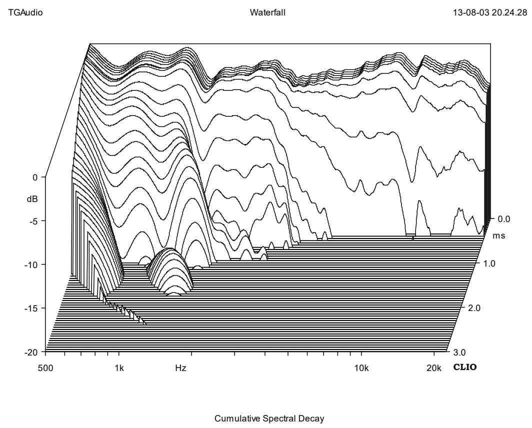


Fig. 41.
From 500 Hz and upwards the response is remarkably free of any form of resonance and it's seldom to have a tweeter performance like this.

Voicing

If balancing a two-way system is tough, a three-way is a nightmare. In particular when one of the drivers has to work in dipole fashion
Looking at all the graphs above, it appears that there may be a broad and small recession in the 800-8000 Hz range. Not exactly what I advocated in the 2.5 clone paper!
The tweeter has some extra level at 8-10 kHz possibly adding some brilliance to the perceived sound (later corrected with LCR circuit).
It's difficult to relate the response readings – clean of any reflections – to the overall perceived sound, as what we hear from the midrange is a result of direct and reflected sound and will vary due to room placement.
The Point75 is in no way deficient in terms of midrange level. Some people will think there's too much midrange and it can take some time to adjust to this kind of midrange presentation.
Thus, the midrange and tweeter attenuation is much done by ear, supported by measurements and CO-tuning to ensure proper performance at points of crossover.

20-08-2003, deadline:

If this report has caught your attention for trying out the dipole concept and ribbon tweeters, I believe you will be rewarded with a sound that will offer you a new entry to your vinyl/CD collection and reveal new qualities of your amplifiers, turntables, tuners and CD-players. Careful crossover tuning and speaker setup is a must to get the best of these boxes.
The Point75 is still a relatively small speaker that can fit into most homes and only needs to be free of the back wall by some ¾ meter.

Thanks to Paulie, US, for the basic crossover design and to Darryl, Australia, for all the discussions that have followed. Also, thanks to Darryl for proofreading the paper. I have learned a lot from all your amendments!

This report will be updated from time to time with possible modifications and new pictures of my final cabinets.

Point75. 2nd chapter

Construction of the final cabinets

Making the final cabinets the length of front panel and side panels were extended by 50 mm to give room for the crossover at the base of the cabinet. This actually required a new set of bass cabinet panels and if of interest I suggest simply adding a base of 40-50 mm height. Or you can require a few sketches from me at troels.gravesen@hotmail.com. This includes cutting plan for side panels and suggested dimensions for bass cab panels. The rest is cut'n try.

Fig.42. Extended front and side panels.

Here's a picture of a possible crossover layout where inductors are placed with greatest possible distance.

Fig. 43. Crossover components.

An equalisation circuit has been added to the tweeter crossover in order to smooth frequency response in the 7-14 kHz region. More on this later.

The LC trap for the midrange and the LCR notch filter for the tweeter will be placed near to the drivers. The high frequency notch filters are very susceptible to magnetic fields from the larger coils, thus the placement near drivers (well off driver magnets as well!).

The bass choke/capacitor will be placed inside the bass cabinet.

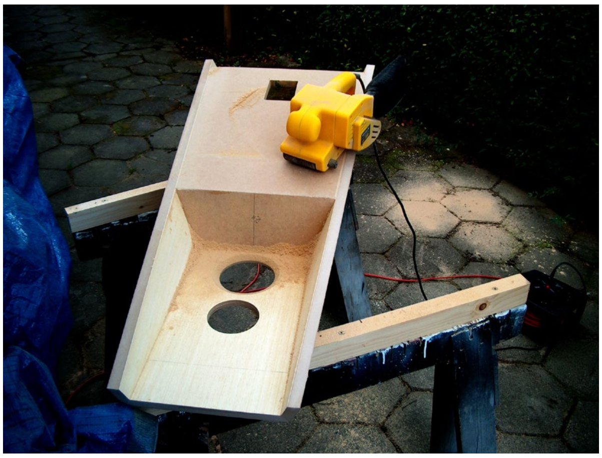


Fig. 44. Sanding the rear of the cabinet.

Fig. 45. Cherry veneer finish.

Fig. 46.

Fig. 47.

Fig. 48. Rear grille support bars, 40 mm wide.

Fig. 49.

Crossover development

The Point75A has now been filling our living room with some great sounds for the last 4 months and a lot of crossover modifications have been tried.

Tweeter equalisation

What has been added is a tweeter equalisation circuit in order smoothing the response in the 7-14 kHz region. The ribbon has an intrinsic raised response in this region, which adds some sparkling sounds to most recordings but also an unnatural presence to voices, strings and brass.

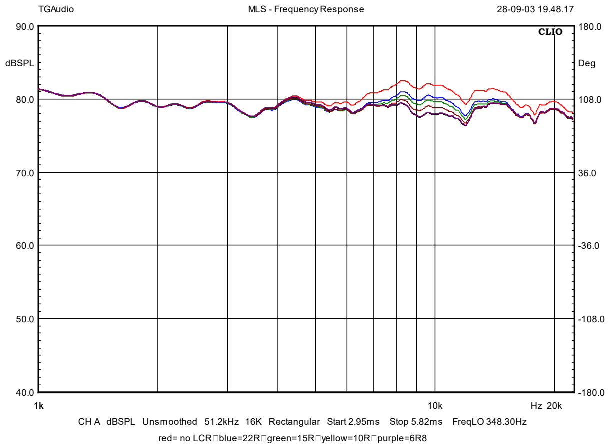


Fig. 50. Tweeter LCR, 0.27 mH + 1.0 uF + R. Red = no LCR Blue = 22 R, Green = 15 R, Yellow = 10 R, Purple = 6R8.

The 0.27 mH coil was changed to 0.15 mH in the final V12. version.

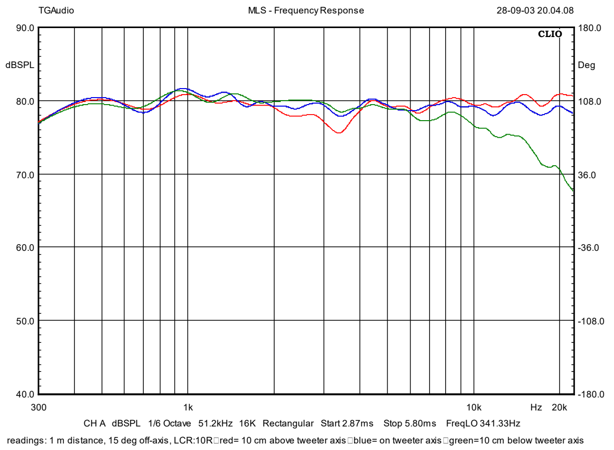


Fig. 51. Tweeter response, various heights. Measuring conditions: 1 meter distance, 15^0 off axis.
Red = 10 cm above tweeter height.
Blue = tweeter height.
Green = 10 cm below tweeter height.
(Differences in response 10 cm above and below are due to the slanted front panel).

With a LCR circuit consisting of 0.27 mH + 1.0 uF + 6R8 an impressive linearity is obtained under these conditions. The elimination of the broad bump from 7-14 kHz has a very positive impact on perceived tonal balance.

Tweeter grille

So, what can be wrong with a 147 € ribbon tweeter? Well, two people have made comments on the performance of the LeRibbon/NDRL81 well in accordance with my own experience. A slightly harsh or sizzly presentation in the very upper treble range; not necessarily lack of detail or lack of speed but nevertheless – something is just not quite right. Taking a look at the tweeter grille, this is a stamped aluminium grille with an approximately 60% opening. Removing the grille doesn't change frequency response, but the sound – more open and unrestrained.

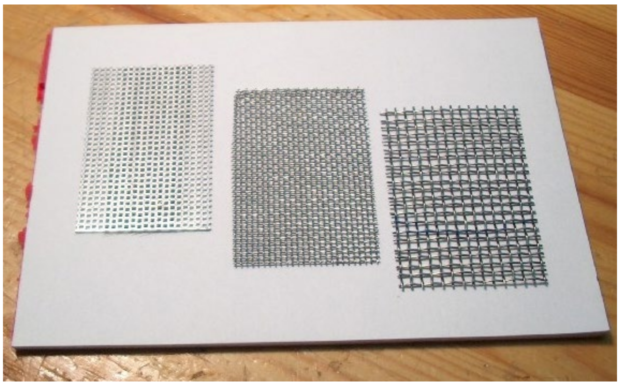


Fig. 52. Tweeter grilles.
Left = original alu grille.
Middle = new stainless steel grille
Right = stainless steel grille with large mesh size.

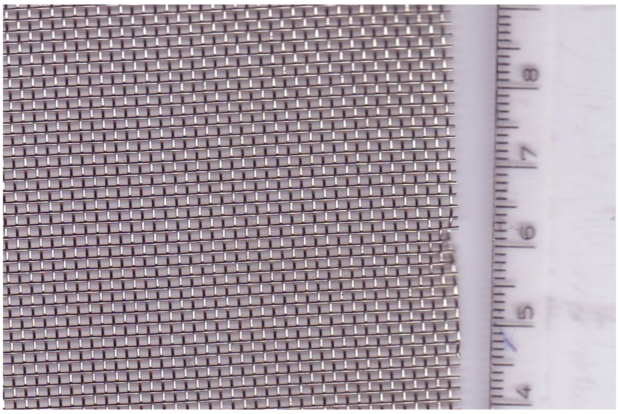


Fig. 53. New grille, stainless steel mesh woven from round threads.

In case you want to try this tweak, take the utmost care when you loosen the screws holding the front plate.

These neodymium magnets are killers!!

Cover the faceplate hole with some thick tape and remove the screws carefully and put them far away.
Remove the alu grille and replace with new grille of stainless steel or brass. The grille has to be made from non-magnetic material and woven from round threads.
The threads in the mesh chosen here are 0.35 mm and holes approx. 1 x 1 mm.
Please don't ask where to purchase the material. Try some local source of fine mechanical engineering, otherwise you may have to buy 2 m^2 or whatever size this material comes in.

Further tweeter modifications

Behind the ribbon sits yet another grille made from stamped aluminium. Removing this grille further enhances the treble sound.

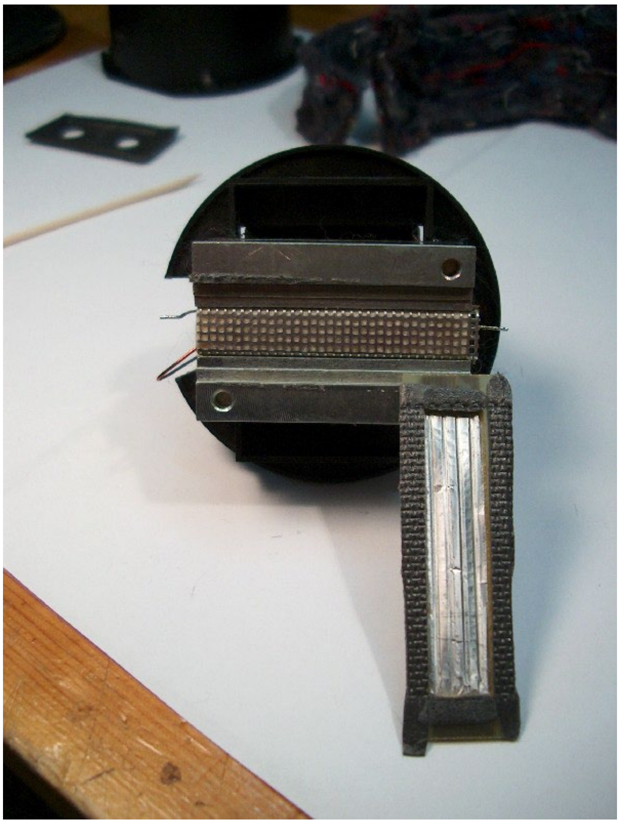


Fig. 54.
The rear grille is removed by pressing it firmly towards the damping material.

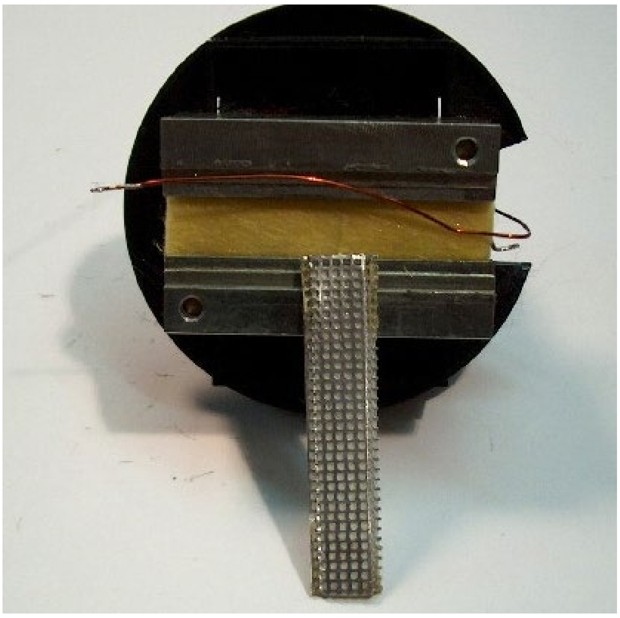


Fig. 55.
The wire seen on the picture is placed in the middle of the damping material in order not to get in touch with the ribbon.

Take care when you solder the wires back onto the ribbon. A thin wooden stick is used to guide the wires as any metal objects are impossible to handle due to the strong neodymium magnets!

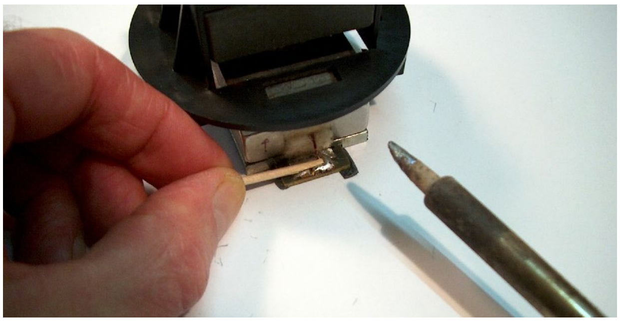


Fig. 56.

Midrange
To further suppress the intrinsic break-up modes of the magnesium cone, the LP-section of the midrange crossover slope has been changed from 18 dB to 24 dB/octave. A 6.8 uF capacitor has been added and the LC trap has been further fine-tuned, now 1.5 uF + 0.22 mH.
The impact of this change can be heard when applying pink noise to the midrange. A small, but significant peak more than 40 dB down is gone.

31-10-2003

Regards
Troels Gravesen
troels.gravesen@hotmail.com

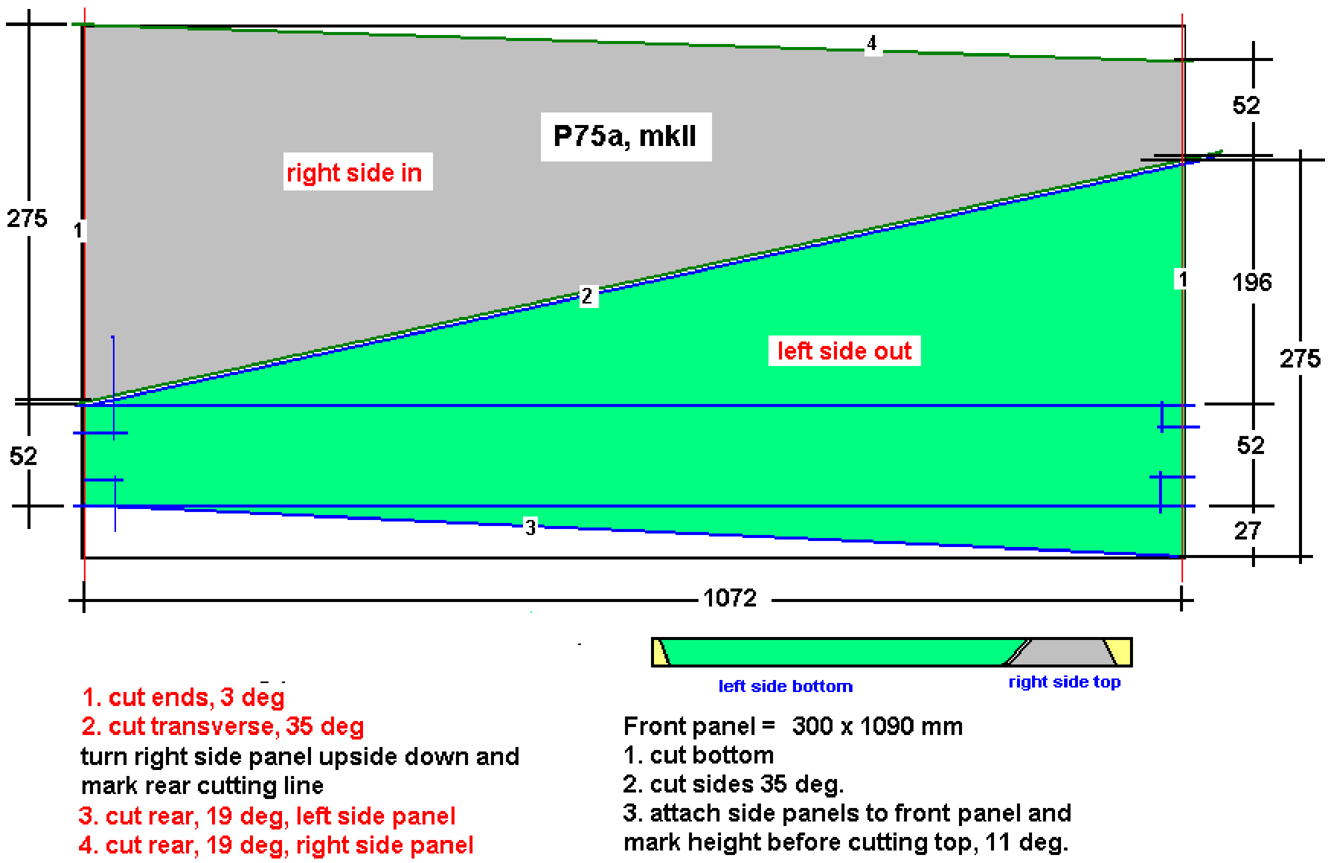


Fig. 57. Side panel cutting plan.

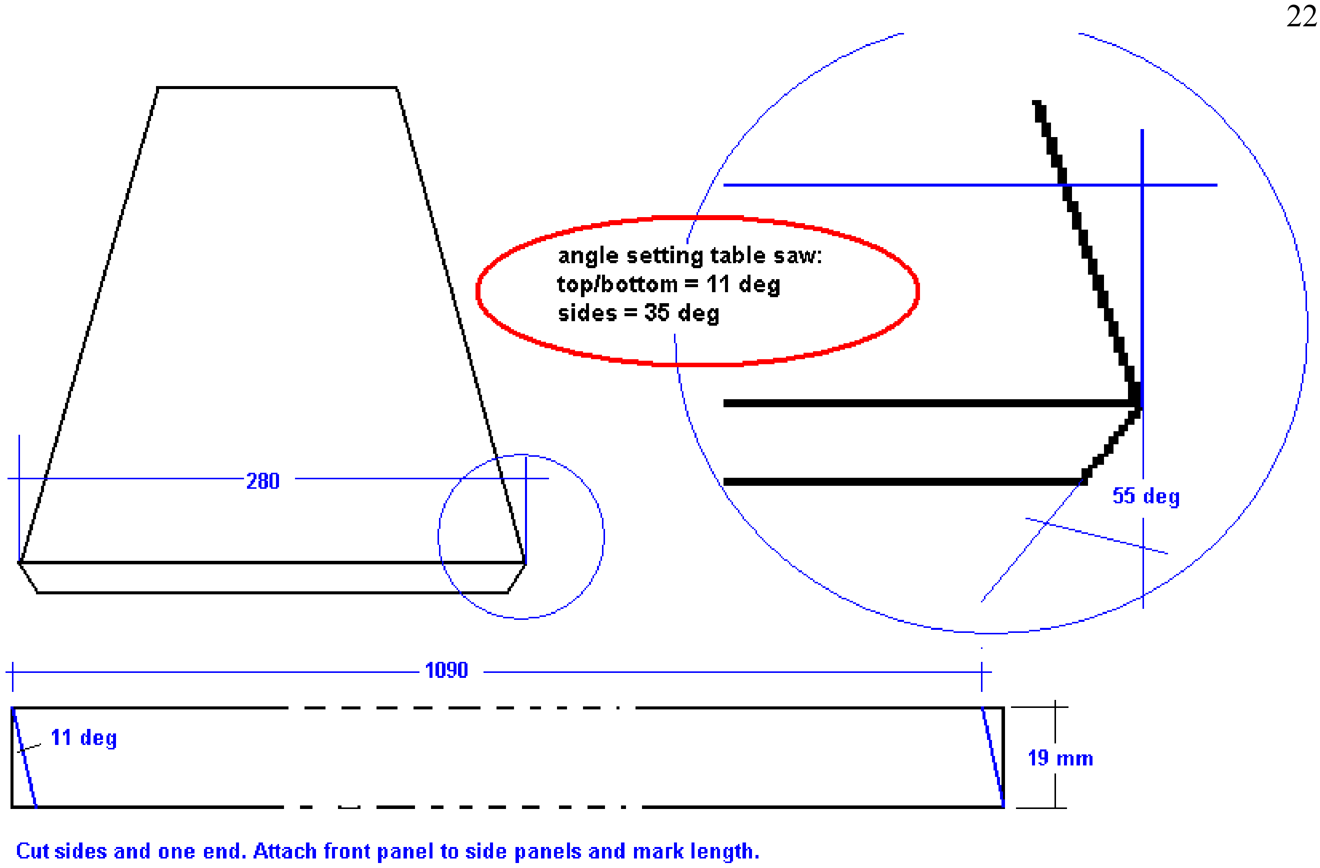


Fig. 58. Front panel cutting.
Cut sides and bottom and leave the front panel 10 mm longer than needed. Determine the length when side panels are ready for a test assembly.

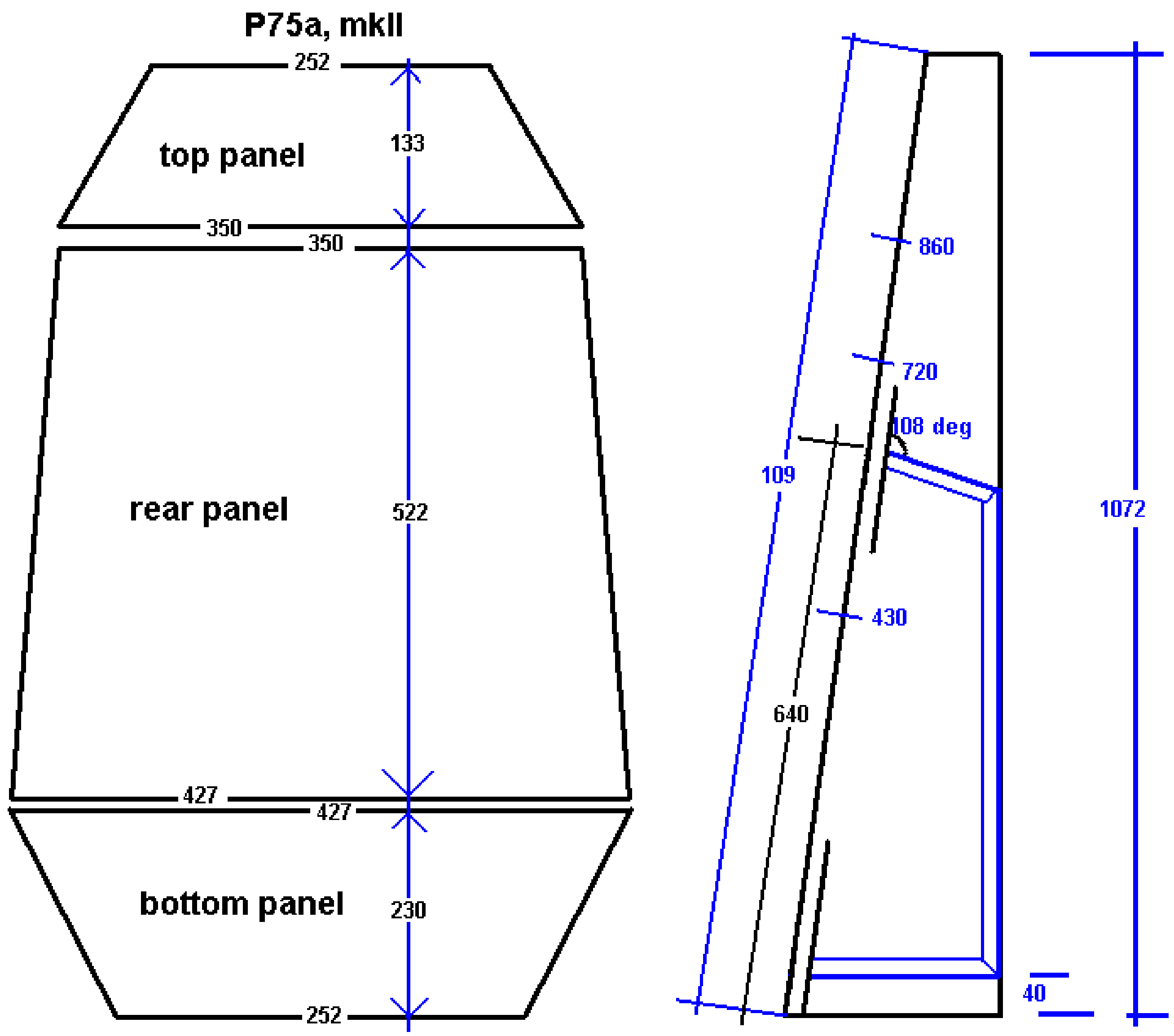


Fig. 59. Bass cab panels.
All bass cab panels have to be cut at various angles and I suggest you use the sliding bevel to determine the angles.
I could include my cutting angles here, but they could be plus/minus 1-2^0 depending on how the side panels fit to the front panels. Better make your own measurements here to get it right.

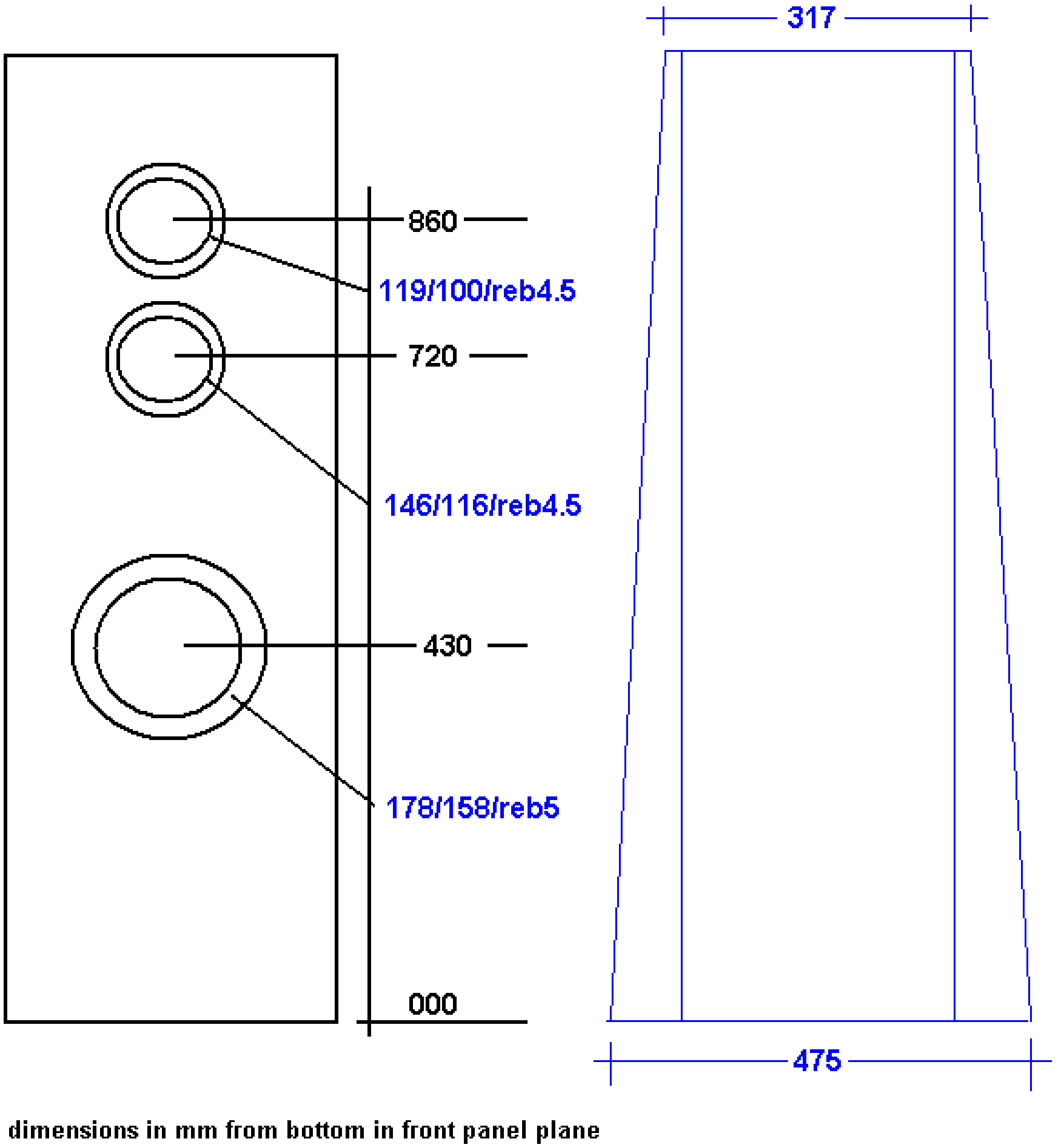
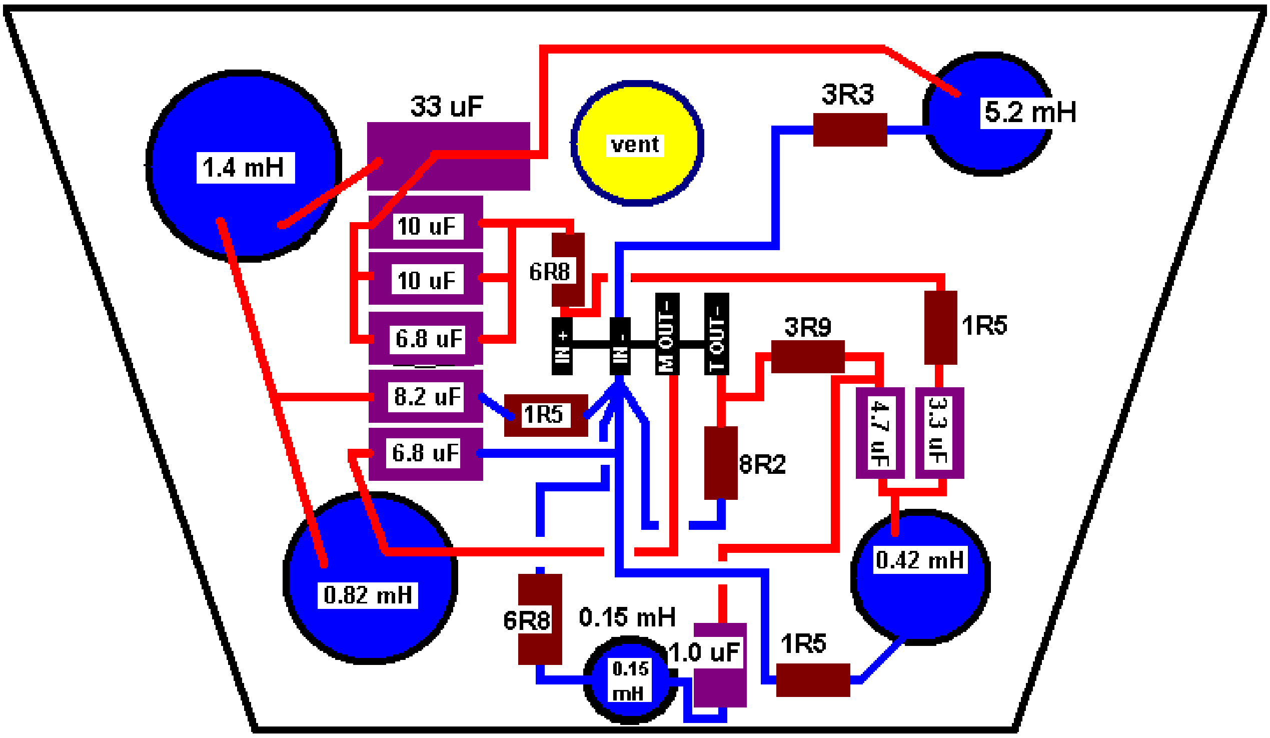
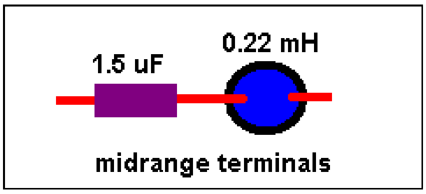


Fig. 60. Routing front panel for drivers.





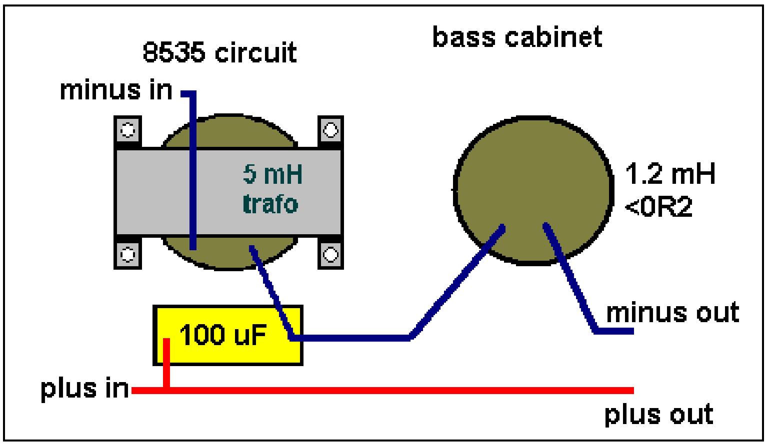


Fig. 61. P75A, crossover layout at bass cab bottom panel. 8535 circuit placed inside bass enclosure.

P75B. Alternative tweeter

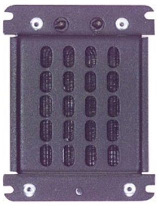


Fig. 62. Bohlender Graebener NEO3 PDR.

So, what's the point of introducing another tweeter at this stage?

Well, the NDRL/ATDs are doing a lot of things very well. The speed and the sparkle and the crisp presentation of percussion and most acoustic instruments is indeed very good, but when it comes to female jazz singers in particular, there's sometimes a pronounced emphasis on "s" and "sh" sounds that could do with a slightly more gentle presentation. The NDRL/ATD is a ruthless tweeter when it comes to less than adequate vocal recordings and I don't think a whole lot of recording studios have ribbon tweeters for monitoring.

A number of tweeters have been tried like the SS 9500, SS 9700 and the Vifa XT25 TG ring radiator, but this didn't seem to be the way to go in supplementing the qualities of the W15 mid driver.
Recently I had the opportunity to listen to the Red Rose Music Rosebud II from Mr. Levinson himself. Listening to a 4,200 EUR/pair of mini monitors I'd expect a decent ribbon to be used and it is a good ribbon, presumably built by Aurus Cantus in China to Mr. Levinson's specifications. This tweeter is crossed at 2800 Hz with a 6 dB filter topology – very bold I must say – thinking of what a small 3.5 cm^2 ribbon has to cope with here. I would order some spare ribbons if I was to buy this speaker!
Point is that the Rosebud didn't do better on vocals than the NDRLs. Hmm…
Maybe it was due to the 6 dB tweeter crossover slope, but really it is not my job to excuse a high-end contender with this price tag.
In the family of drivers, planars are new to me and I've for some time been thinking of the Bohlender Graebener NEO3 PDR driver and a guy here in Denmark even offered to lend me a pair of drivers (the NEO3) for a low-cost version of the P75. Apparently, the PDR version offers improved response and horizontal dispersion and a pair was ordered from ELTEK, Norway. I can only recommend this dealer as a fast and reliable supplier of drivers in general. But expensive. US citizens will get away with 1/3 at www.partsexpress.com of what we pay here. I bought a pair of the drivers fitted with faceplates and a rear chamber:

Fig. 63. NEO3 PDR tweeter with face plate.

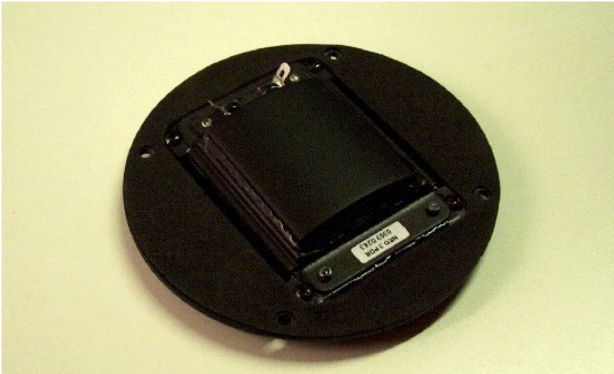


Fig. 64. NEO3 PDR, rear view.

First of all: forget about the faceplate and the rear chamber. The faceplate makes it an easy substitute for poor tweeters and the rear chamber is approximately 3 mm deep, flat and loosely filled with some very poor damping material. The faceplate ruins the frequency response and the rear chamber applies a load to the membrane that enhances low-end response, but also produces a whole lot of coloration. Off they go.
The NEO3 PDR requires a mounting hole of 38 (W) x 56 (H) x 10 mm (D), chamfered 45^0 like this:

Fig. 65. NEO3 PDR, flush mount faceplates.

Frequency response of the NEO3 PDR driver with wooden faceplate:

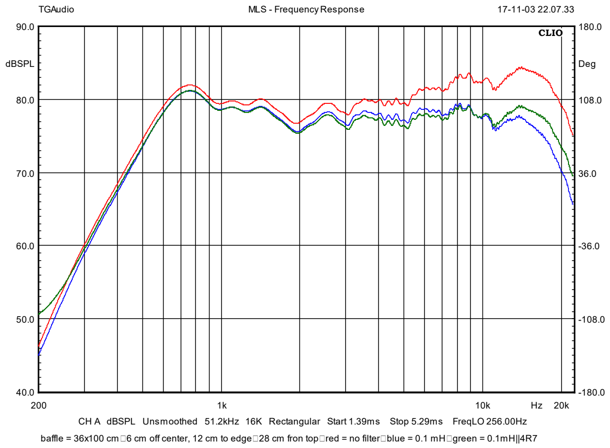


Fig. 66. NEO3 PDR frequency response.
Red = no filter.
Blue = 0.1 mH in series with tweeter.
Green = 0.1 mH coil bypassed by 4R7.

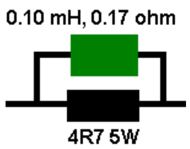


Fig. 67. Equalisation circuit.

With no filter added, the tweeter has a relatively smooth rising response from 2 kHz to 15 kHz. Adding a 0.1 mH coil flattens the response and bypassing the coil with 4R7 further improves the response above 12 kHz. So far, so good. Now we can start to target the point of crossover at ~ 3 kHz.
To cut a long story short this is what was achieved:

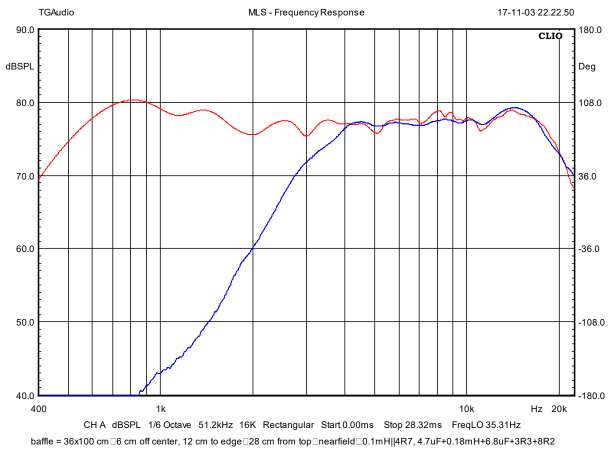


Fig. 68. NEO3 PDR with final filter.
Red = only equalisation circuit.
Blue = 18 dB filter, fig. 69.

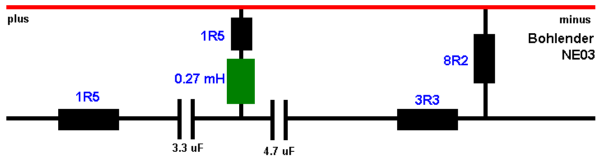


Fig. 69. NEO3 PDR crossover.

In front of this a series resistor can be added to match the response of the W15 driver.

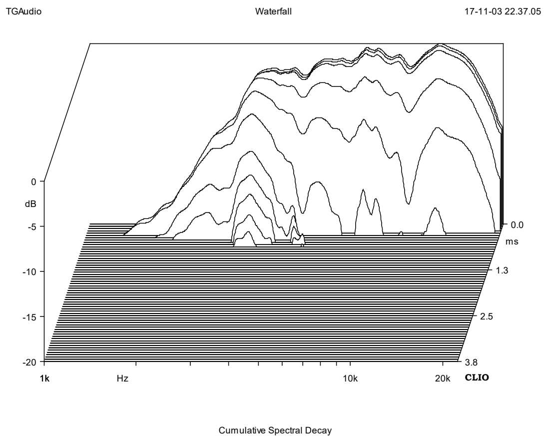


Fig. 70. NEO3 PDR, Cumulative spectral decay with crossover added.

Making inserts that fit the NEO3 PDR drivers into the holes of the NDRLs wasn't an easy task.
Flush mount faceplates can be purchased from www.partsexpress.com.

Sound of the NEO3 setup

The NEO3 PDRs sound somewhat different from the ribbons. They do not have the "tizz" sound that characterises the ribbons, if you know what I mean. The midrange/tweeter integration is slightly improved, and female vocalists gain a more true presentation and the speaker becomes more tolerant of less than good microphone practice.
Working in a dipole mode all the way up from 300 Hz adds to the soundstage and I haven't noticed any problems with this, even with the speakers placed only 0.7 m from the back wall.
I'm not saying the NEO3s are better than the ribbons, but they are more tolerable on poor recordings and sometimes we have to compromise and take into account the real world of recordings.

Point75A & B fine tuning

After some work on the descendants of this speaker, the Acapella, the roll-off characteristic of the bass driver came into focus again.
The 8535 unit is a lively driver with some capabilities beyond 2000 Hz, and a 12 dB roll-off produces the following result:

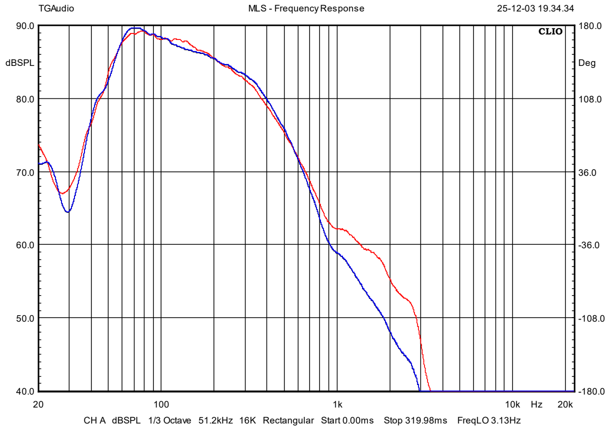


Fig. 71. Bass nearfield response.
Red = 12 dB filter, blue = 18 dB filter
Some may think that what happens some 30-40 dB down will not have an impact on the neighbouring driver, but it has.
Actually the tweeter and the bass driver kiss hello at 2800 Hz some 35 dB down. Adding a second coil to the bass LP section produces the blue graph and this has a positive audible impact on midrange/lower tweeter response.

In order to ease the load on the midrange driver, the LP section was subsequently changed from 12 to 18 dB, thus the revised v12 crossover at page 11, fig. 31.
I'm not sure of the audible impact of this modification, but the cost is small and the less bass the W15 has to handle the lower the distortion.
A 3R3 resistor is added to the 5.2 mH coil to smooth the roll-off characteristic.

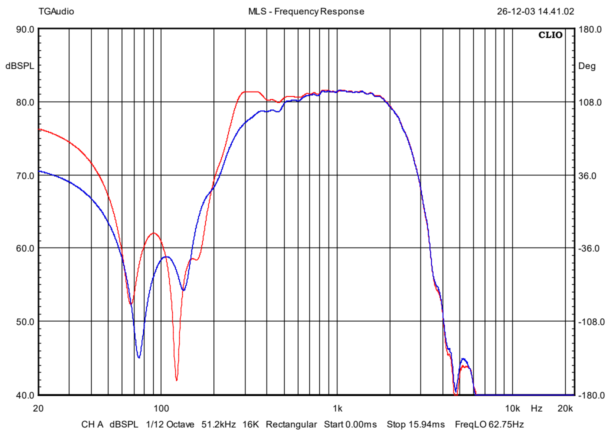


Fig.72.

Blue = midrange response with modified crossover, v.12.
(red = no resistor to coil).

The modifications apply to both the A and B version and have a positive impact on higher midrange/lower treble performance.
With these mods the differences between the NDRL and the NEO3PDR have become less apparent and still I would say the NEO3 version has a slightly softer presentation compared to the ribbon version.

26.12.2003

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homepage:
http://www.troelsgravesen.dk/Diy_Loudspeaker_Projects.htm