Auriga

The Auriga – a dynamite speaker!

Concept

After building a few compact "book-shelf" type speakers it was time for a floorstander. It had to be something with good efficiency, something my TG84 tube amp could drive easily, not too big and it should look a little different.

My favourite 2,5-way concept should meet these requirements. Most 2,5-way designs I have seen are basically a standard two-way to which an extra woofer is added for more bass. So you get a large inductor in series with the mid-woofer lowering efficiency and therefore the maximum dynamic range. The second woofer is then added parallel also with a large inductor in series (something like 10 to 15mH). The result is nice deep bass from a relatively small floor standing cabinet but the speaker never seems to come alive.

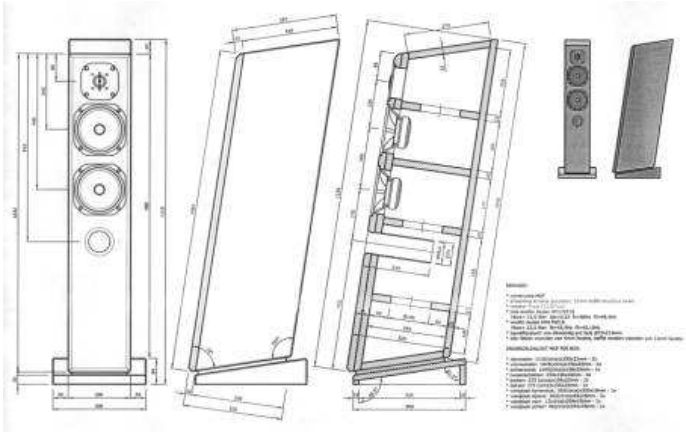
I take a different approach: I use the second woofer to compensate the so-called baffle-step. So the bass is only as deep as with a normal two-way but efficiency is much better. The upper mid-woofer can give its full potential not being constrained by a large inductor and you still have twice the cone area radiating in the bass and lower midrange region to be able to move enough air. Ideally the lower woofer should be identical to the upper mid-woofer and should be blended in smoothly with a simple 1st-order filter giving minimum phase shifts in the crossover region for a seamless integration of the two units. Using two internally separated cabinets, the upper volume for the mid-woofer being closed and the lower volume for the woofer being reflex, it is possible to combine the best of both worlds. The closed upper volume gives a nice tight and controlled bass and midrange, where as the lower ported volume gives more bass depth.

Cabinet construction

Okay, a different shape. How about a good old "form-follows-function" cabinet? The Proteus is a MTM so this speaker should be a TMM. This means that to bring all drivers into alignment for correct phase integration the baffle must be sloped backwards.

This was the basis to make the whole cabinet angled. But building an angled cabinet can be rather difficult if you don't have precision tools, etc so I had an idea how to get around this problem.

The cabinet is constructed from two layers of mdf glued together. Basically you build a 22mm internal cabinet and sand all the joints and ends so that it is nice and smooth. The baffle is made extra thick and uses a double layer of 22mm mdf (44mm total) – see the photo below. There will be the odd little gap or leak here and there because it is practically impossible to get all the angles to fit together 100% perfect. Then you cover the 22mm thick cabinet with a second layer of mdf with a thickness of 8mm so the total wall thickness adds up to 30mm. Due to the layered structure with varying density this is much more solid than one single layer of 30mm mdf. The 8mm layer is left out of the CAD-drawing.



The CAD drawing.

The outer 8mm mdf is then sanded to make a nice airtight cabinet. Then comes the trick to make the construction look very professional as if all panels were cut to the perfect angle and no panel thickness is visible: cut all edges with an 8mm facette at a 45 degree angle (the same as the thickness of the visible layer) using a router. The photo will explain better what I mean:

The extra 8mm layer of mdf is visible before painting.

Using this double-layer trick it is also possible to use standard PVC drainpipe for the reflex port and still make it look very professional as if the port is one with the cabinet. Before I placed the 8mm mdf layer on the cabinet I made the circular cutout for the tube and glued the tube into place. Then I sanded the end so it was perfectly flat and level with the front of the 36mm baffle. Then the extra 8mm layer went on and at the position were the reflex port was I cut out a rough hole so I could fit my router in. Then I routed a 8mm facette at a 45-degree angle again so that the 8mm mdf stops exactly were the PVC tube starts. Again the photo will explain better what I mean:

The mdf/PVC connection for the reflex port.

All internal walls are covered with heavy-duty carpet tiles to minimise vibrations and standing waves. The carpet tiles have a nice heavy backing that adds mass to the enclosure and they come in all kinds of lovely colours and patterns. Glue them to the MDF using lots of carpet glue. Adding a few screws or nails helps hold them in place and stop them curling up while the glue dries.

The lower reflex cabinet uses bonded acetate fibre damping material rolled up and placed directly behind the woofer. Depending on the positioning of the speakers in the room and personal taste this fibre can be rolled up densely or loosely to give a tighter and dryer or a fuller and warmer sounding bass. I used Monacor MDM-3 damping pads that consist of 2/3 sheep's wool and 1/3

polyester fibre and found that one bag per speaker was okay. If you have a small listening room or your speakers have to stand close to a wall then maybe some extra fibre filling the reflex the cabinet will be necessary.

The upper closed cabinet is filled with 100% Rockwool, a small piece of BAF is placed over the Rockwool directly behind the midwoofer to stop any bits of the damping material coming in contact with the cone and other moving parts (don't forget the Audax HM170Z18 has ventilation openings on all sides!).

The cabinet is placed on a T-shaped solid wooden foot. The foot is then spiked to floor. To create a stable construction (the cabinet only rests on three points of the foot) I used steel wire to form a triangle to stop any sideway movement of the cabinet on the foot. You can let your imagination go for the foot; any other shape will do as long as the baffle slopes back at about 8,5 degrees.

The T-shaped wooden foot and in the background the panels for the speaker grille.

The tweeter

The Focal TC120Tdx2. This high sensitivity tweeter features Focal's inverted Tioxid dome and a large magnet structure. It consists of a super high modulus dioxide coating on a titanium dome with specially treated surround and Ferro fluid cooling. The faceplate is made of 5 mm thick Zamak alloy and also features a unique phase plug to help control the dispersion throughout its frequency range. As with all Focal tweeters they sound terrible straight from the box! They need at least 3 weeks to mature and get rid of their harsh and cold sound. Focal has recently replaced this model with the TC120TD5 for which I have also designed a crossover. Unfortunately the older model sounds better, a little smoother.

The Focal TC120Tdx2 and one of the Audax HM170Z18's.

The mid-woofers

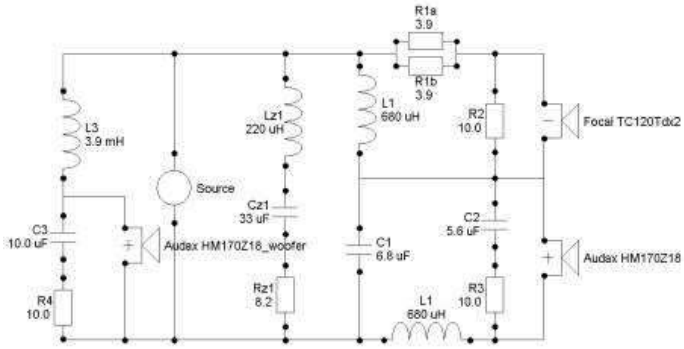
The Audax HM170Z18. The HDA cone is made of a unique acrylic polymer gel with a blend of Kevlar and carbon fibres embedded into it. During the production process, the HDA matrix goes through a gel phase, which has the particular property of orienting all the polymer chains along a uniform axis, contributing to the stiffness of the cone and giving it very high internal damping properties. Using the HDA manufacturing process, it is possible to produce ultra light cones that are much stiffer than standard technologies. Compared to paper for instance, - currently the material with the most favourable weight/stiffness ratio -, HDA is 70% stiffer at the same weight, or 30% lighter at equal stiffness.

The crossover network

This was a difficult one this time! The problem was that because the drivers are so easy to filter nearly every filter configuration sounds good (not perfect but good). This made it rather difficult to decide in which direction I should go. After several experiments with crossover points between the mid-woofer and the tweeter at about 2000-2500Hz I came to the conclusion that the Focal tweeter doesn't like being crossed too low. Not that 2200Hz is low but crossing in this area made the tweeter lean towards the harsh side with some recordings. It didn't matter if I used 1st, 2nd or third order filters, it just didn't feel right. So I shifted fx up to the 3000-3500Hz region and everything fell into place. The Audax HM170Z18 has no problems with this relatively high crossover

point and the Focal tweeter sounded much more at ease. The tweeter became sweeter. After extensive listening tests I ended with the following filter:

It is a 2,5-way design with the woofer connected parallel across the series section of the tweeter and mid-woofer. Experiments with integrating the woofer into the series part of the crossover gave a slightly more "one-ness" of the drivers but at the cost of about 2dB in efficiency. Seeing as high efficiency was one of the main design criteria (which I wanted to keep to) I opted for the parallel/series configuration. The woofer rolls off smoothly with a nice and simple 1st order crossover using a single transformer type inductor and a RC-network to correct the impedance rise *and* tailor the output in the midrange. The RC-network acts as a fine-tuning instrument to blend in perfectly the woofer with the mid-woofer. The series section of the crossover is an a-symmetrical type, sort of 1st order with an extra inductor in series with the mid-woofer (or a second order series network with one of the capacitors left out). This gave the best balance between openness/spatiality and neutrality/smoothness.



The updated crossover (09-12-2002).

Filter components: (between brackets for the TC120TD5)

L1 = 0,68 mH air-core inductor 2,00mm wire, R=0,13 ohms

L2 = 0,68 mH air-core inductor 2,00mm wire, R=0,13 ohms

L3 = 3,9 mH E96 transformer type inductor, R=0,16 ohms

Lz1 = 0,22 mH air-core inductor 0,71 mm wire, R=0,5 ohms

C1 = 6,8uF MKP polypropylene foil capacitor

C2 = 5,6uF (6,8uF) MKP polypropylene foil capacitor

C3 = 10uF MKP polypropylene foil capacitor

Cz1 = 33uF MKP polypropylene foil capacitor

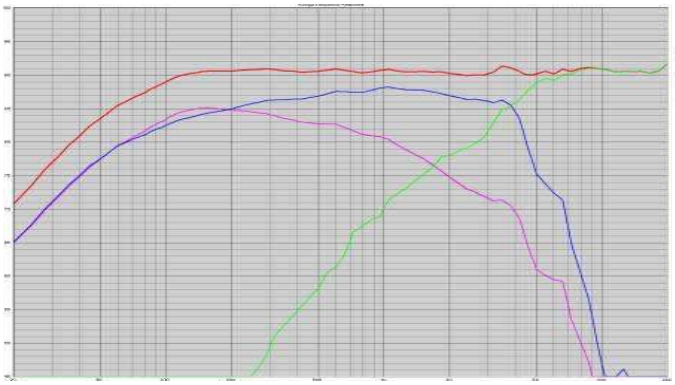
R1 = 1,8 ohms (2,0 ohms) 10 watts metal film resistor – 2,2 ohms gives a warmer overall sound - 1,5 ohms sounds a little brighter.

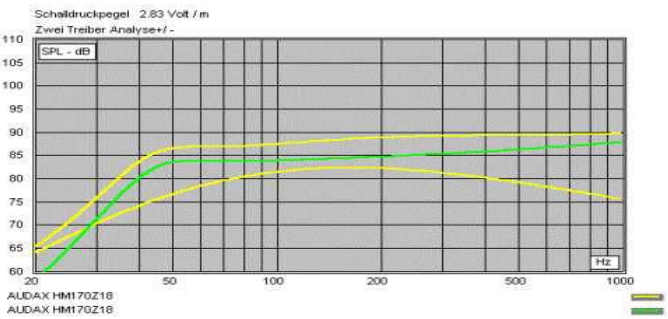
R2 = 10 ohms, 10 watts metal film resistor

R3 = 10 ohms, 10 watts metal film resistor

R4 = 10 ohms, 10 watts metal film resistor

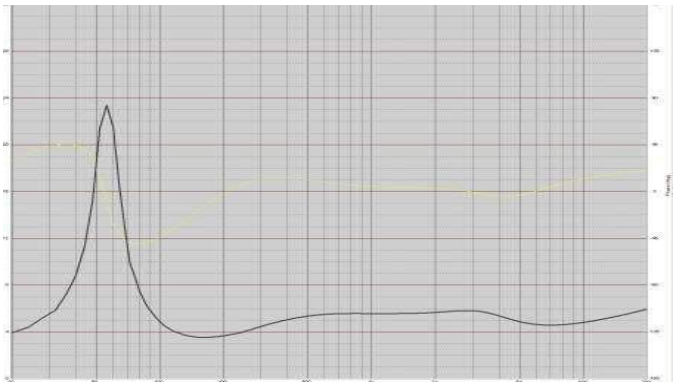
Rz1 = 8,2 ohms, 10 watts cemented resistor





The output level shows a very linear response within +/-0,5dB except for a little peak at 3500Hz. Trying to filter it out caused more problems than it solved so I left the correction out. Because the peak is so narrow that it is in audible in music. The horizontal scale is 1dB so the peak looks worse than in normal, more flattering, graphs. Even taking the peak into account still gives a +/-0,75dB curve. The drop in the bass below 100Hz is due to the free-field closed box simulation; the real life reflex loaded bass will be at the same level as the rest with a –3dB point of about 40Hz (see second graph). I must stress that this second graph doesn't take into account the lift of the bass and lower mid-range region when placed in a real room but it does show the baffle step that is compensated by the lower woofer. In an average size room with rear wall support the response is very even over the

whole spectrum. The crossover points are at 400Hz and 3000Hz with a perfect –6dB point for the mid-woofer and tweeter at fs. This indicates nice phase integration at the crossover region.



The impedance curve for a closed box simulation. The main horizontal division is 4 ohms with sub divisions of 1 ohms +/- 1 ohm over the whole range except for the bass impedance peak (the reflex will show two peaks).

Listening impressions and remarks

After working with small (and less efficient) speakers for a while the first thing I noticed with these speakers was their high efficiency. I kept turning the volume knob to high, so every time the music started I had to rush to my stereo to turn it down! I would describe these speakers as being very lively and dynamic. There is a certain "speed" and "drive" to the music. All frequencies are portrayed with lots of detail and forwardness but it never gets too much. They let you look into the recording and pinpoint every instrument or vocalist. The dynamic range seems very large, pianissimo parts stay soft without any loss of clarity and on the other extreme they can play very loud without compressing the music. Don't expect earthquake bass from them, they are still only 7-inch woofers but the low end is full-bodied and tight. The bass-reflex / closed combination really pays off here.

Tony Gee, The Netherlands

October 2002, updated December 2002