Galactica

The ultimate cosmic speaker experience

Big, powerful and an extraterrestrial experience! This is what happens when I have the opportunity to design a loudspeaker that doesn't have to meet the standard "rules" concerning size. I can go for my ultimate bass configuration using a 12" midwoofer and 15" woofer combined with one of the best midrange drivers available today and a complementing tweeter.

The woofer

For me a 15" woofer is the ideal size for realistic sounding bass. It is big enough to give that "ease" that comes with larger woofers, it is small enough not to compromise the upper-bass range articulation and integration with the rest of the speaker. I specificly say *woofer* and not *subwoofer* because this driver will be used from about 30Hz up into the lower part of the midrange, so it will cover the fundamental notes of most bass instruments without having a crossover-point in this range. The woofer used here is the Ciare NDH 15-4S. Ciare call it a subwoofer, but that is looking at it from a PA point of view. This driver has very low mechanical losses (high Qms), a very powerful magnet (low Qes) and with a resonance frequency of about 28Hz it will go plenty low enough. Here it is used in a closed box with a nett volume of 60 litres resulting in a Qtc of about 0,55 for nice deep, punchy bass. I used a closed box to keep the whole system relatively compact.

The midwoofer

The woofer used here is the PHL 4531 . The PHL 4531 is the new version of the well known 4530. I chose this driver for it's very smooth frequency curve and good balance between bass-extension and midrange qualities. I was also looking for a specific system SPL that would integrate nicely with normal Hi-Fi-tweeters without the use of resistor networks in the midbass. Here I used the PHL 4531 in a reflex box with a nett volume of 60 litres and a rear-firing port tuned to 44Hz. This gives a theoretical -3dB-point of about 47Hz but in combination with the Ciare NDH 15-4S and the crossover, the system -3dB-point is shifted down to about 30Hz. I chose a ported enclosure because I found this to give a more open and dynamic mid-bass than a closed box. Seeing as the 15" woofer was already in a closed box, the two together should give a nice balance of bass-weight, depth and punchy-ness.

The midrange driver

A matching midrange driver for this project was also found at PHL: the PHL 1130 . In the past I have often worked with the 6,5" midwoofers from PHL and was always impressed by the articulate and expressive midrange qualities. Seeing as here the bass and upper-bass would be done by dedicated drivers, I could go for a true midrange driver. PHL makes lots of different versions but carefully searching through all the data I came up with 4 possibilities: the 1120 / 1130 / 1660 / 1670. All four drivers are designed for use in high quality studio monitors, the 1660 / 1670 models have a little more power in the lower midrange but seeing as the 12" PHL 4531 would take care of that, the 1120 / 1130 seemed a more logical choice. The only difference between these two models is their impedance. As I prefer to get the highest possible BL/Mms ratio I decided on the PHL 1130 with its 16 ohm nominal impedance. Its BL-factor of 12,7 is about 1,5x that of the 8 ohm version and with a moving mass of only 8,2 grammes this results in an amazing BL/Mms ratio of 1549. Now compare that with other drivers with 150 square centimetres of cone-area!

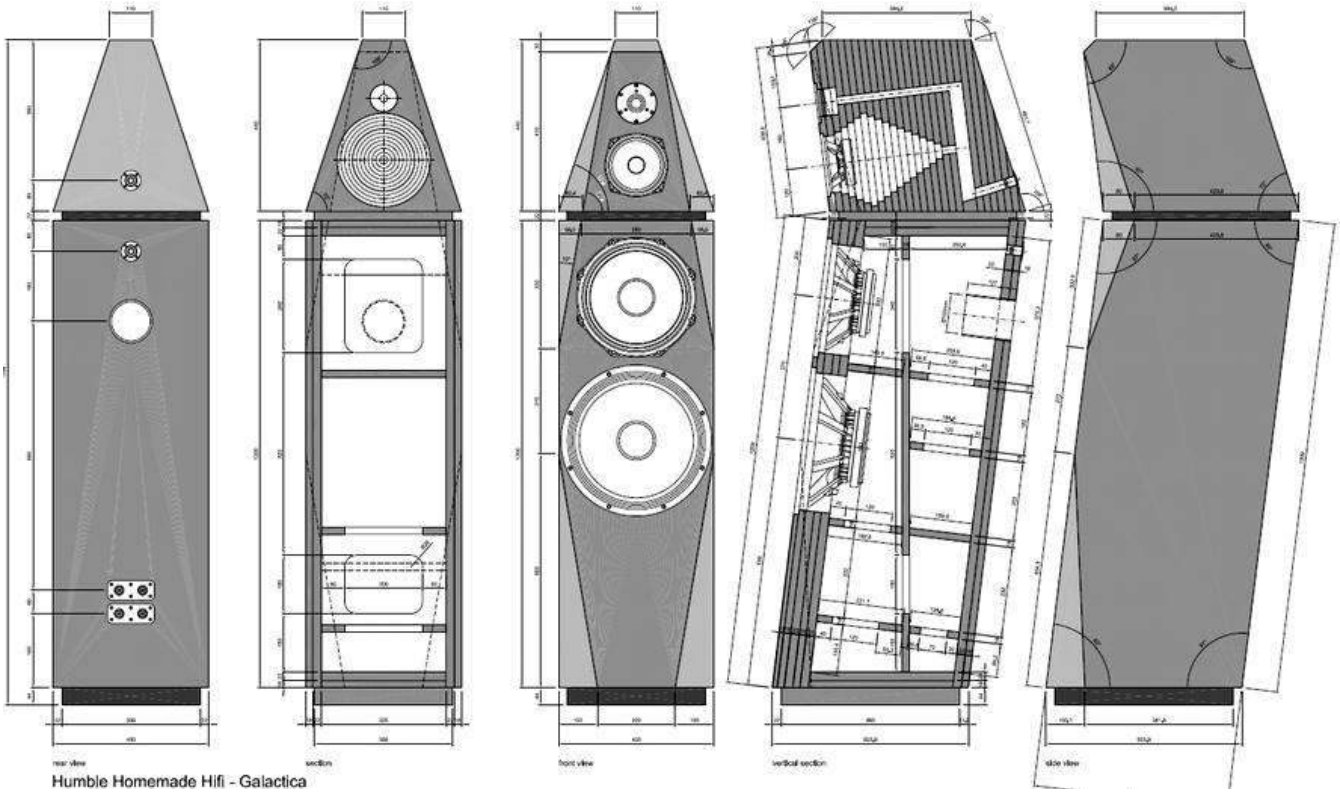
The tweeter

Seeing as the Galactica speaker uses paper cones for the bass, midbass and midrange, the logical choice when looking for optimum driver coherence, was to choose a soft-dome tweeter. Now I needed a very high quality driver with reasonable efficiency and a nice low resonance frequency to facilitate crossover design. I found these qualities in the Seas Excel T29CF001-E0038-06. The T29CF001 is a 29mm fabric dome tweeter with a wide surround. An optimally shaped dome and integrated wide surround manufactured by SEAS from SONOMEX ensure excellent performance and consistency. A powerful magnet system based on an axially magnetized NdFeB ring magnet provides efficient ventilation and damping of the cavity behind the dome. Low viscosity magnetic fluid provides excellent cooling while maintaining a low resonance frequency. A generously underhung voice coil with flexible lead-out wires ensures low distortion and allow this driver to be used with low crossover frequencies. A 6mm precision machined aluminium front plate with moderate horn loading combines linear frequency response with high efficiency. The front plate is Nextel painted to obtain a durable and attractive finish. A substantial injection moulded rear chamber made from zinc eliminates unwanted chamber wall resonances and conducts heat away from the magnet system.

The cabinet

First of all this is a very complex, heavy and time-consuming loudspeaker to build so take your time and double check everything before you start. These cabinets were built by Ruud "Toto" from The Netherlands. The just over 1,7 meter tall cabinets are made of various combinations of 12mm, 18mm and 22mm thick mdf. There are two seperate sections, the lower bass cabinet is heavily braced and has a contrained layer baffle with a total thickness of 92mm's. The reflex-port on the rear has an internal diameter of 100mm's, the total length of the port is 127mm. The baffle has 45-degree corner "slices" cut off to make it look more and to minimize diffraction from the baffle edges.

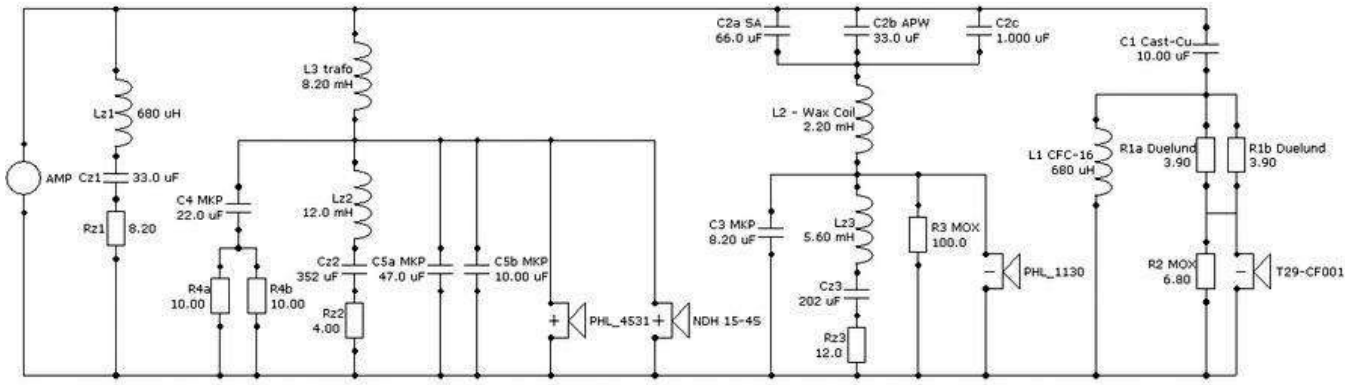
The top section for the midrange and tweeter is made from numerous slices glued together to form a nearly soild block. The midrange volume is created by con-cenctrical places circluar cutouts in each layer. Furthermore there are channels for the cables of each individual driver to the connectors on the rear. A higher resolution drawing of the cabinet is available on request.



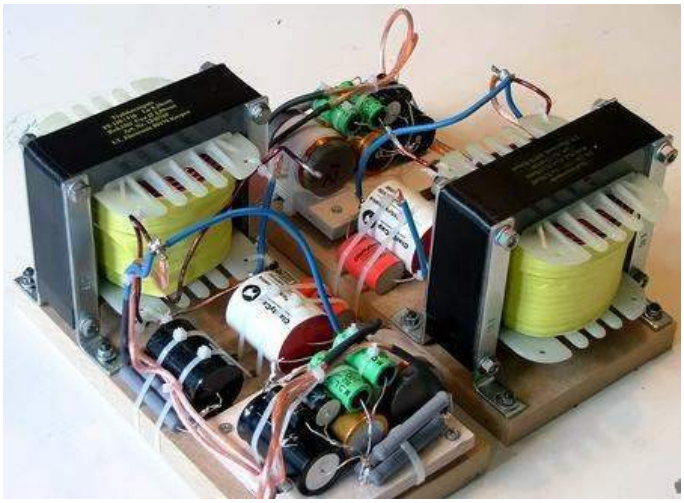
All the internal walls of the bass enclosure are covered with Intertechnik Damping-30 damping material. This 30mm thick, self-adhesive material is made from recycled cotton. The internal volumes for the Ciare NDH 15-4S and PHL 1130 have a medium to heavy fill of Monacor MDM-3 damping material that is made from 75% sheep's wool and 25% bonded acetate fibres. The vented enclosure for the PHL 4531 has a very light fill of the same stuff, tune the correct amount for each compartment by ear when the drivers are burnt-in. Don't forget to use dedicated gasket sealing strips like Monacor MDM-5 between the counter-sunk driver chassis and the mdf cabinet for an air-tight fix. Internal wiring is standard 2,5mm2 OFC for both woofers and silver-plated OFC in PTFE for the tweeter and midrange drivers.

The crossover network (the hart and soul of the loudspeaker)

These four drivers are connected together via a 3-way parallel crossover, the 12" and 15" woofers run in tandem. The crossover schematic may look a little complex but basically each driver has a simple 2nd order parallel leg except for the midrange driver that has a 1st-order high-pass.



The low-pass for the woofers is formed by 8,2mH + 57uF. For the inductor low Rdc is extremely important if you want tight and well-controlled bass. A transformer type with a 130mm core is not a luxury! Also the 57uF parallel to the woofers must be MKP types, cheap standard types like Clarity Cap APW work fine. The result is better bass definition compared to using cheap smooth foil electrolytics. The LCR-network parallel to the woofers is to flatten the impedance peak in the bass so that the low-pass function works properly, without this LCR there is a large bump at lower frequencies resulting in an over bloated and muddy sounding bass. Furthermore there is a Zobel-network parallel to the woofers to flatten the impedance rise at higher frequencies, also to ensure that the low-pass network will function accordingly.



The midrange driver covers the spectrum from about 250Hz to 2050Hz. The high-pass is formed by an array of parallel capacitors making a total of 100uF and the low-pass is formed by 2,2mH + 8,2uF. To keep the cost of the relatively large value of the series capacitor down I connected several MKP types parallel of which I find they have a very good price/quality ratio – in this case Clarity Cap APW and SA with a little 1,0uF as bypass. Anything less would compromise the very high quality of the midrange. The series inductor is a copper-foil with paper in bee's wax type for best imaging, separation and natural harmonics. A single parallel resistor brings down the level of the midrange driver just a fraction to blend in perfectly with the rest. There are no other resistors in the midrange signal-path except the Rdc of the Wax Coil. The LCR-network parallel to the PHL 1130 flattens the impedance peak at fb so that the high-pass function works properly, without this LCR there is a bump in the lower midrange.

Finally the tweeter high-pass consists of 10uF + 0,68mH. For C1 personal taste and budget will determine what you use, I had very good results with a Duelund Cast-Cu (my current capacitor reference). The parallel inductor must be a foil-type but it doesn't need to have low Rdc. I found a foil type here to sound more spacious than a standard air-core even though it isn't directly in the signal path. Finally there is a resistor combination that dials-in the tweeter level to match the rest of the system, R1 is very important for the overall perceived quality of the treble. I advise Duelund Silver Graphite for its smoothness and detail. This resistor combination also smooths the tweeters impedance so that the high-pass network functions properly. If you want to add some top-end "air" (a matter of taste) you can bypass R1 with a small high-quality capacitor of between 0,47uF to 1,0uF.

C1 = 10uF Duelund CAST Cu Paper-In-Oil

C2a = 66uF (3x 22uF) Clarity Cap SA

C2b = 33uF Clarity Cap APW

C2c = 1,0uF Paper-in-Oil Alu or something to your taste

C3 = 8,2uF Clarity Cap APW

C4 = 22uF Clarity Cap APW

C5a = 47uF Clarity Cap APW

C5b = 10uF Clarity Cap APW

Cz1 = 33uF Clarity Cap APW

Cz2 = 330uF bipolar + 22uF Clarity Cap APW

Cz3 = 200uF bipolar + 2,2uF Clarity Cap APW

L1 = 0,68mH Jantzen 16AWG copper foil inductor (Rdc = 0,31 ohms)

L2 = 2,2mH Jantzen 16AWG Wax Coil (Rdc = 0,55 ohms)

L3 = 8,2mH Intertechnik E-130 transformer inductor (Rdc = 0,15 ohms)

Lz1 = 0,68mH air-core inductor 0,70mm wire (Rdc = 0,60 ohms)

Lz2 = 12,0mH correction inductor (Rdc = 1,44 ohms)

Lz3 = 5,60mH correction inductor (Rdc = 0,85 ohms)>

R1a = 3,9 ohms Duelund Silver/Graphite resistor

R1b = 3,9 ohms Duelund Silver/Graphite resistor

R2 = 6,8 ohms 10 watts MOX resistor

R3 = 100 ohms 10 watts MOX resistor

R4a = 10 ohms 10 watts MOX resistor

R4b = 10 ohms 10 watts MOX resistor

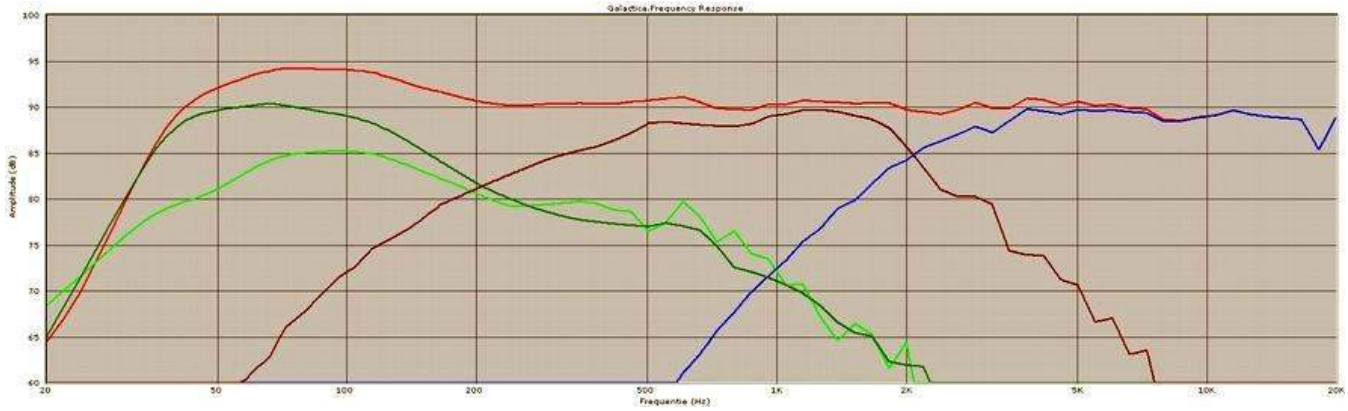
Rz1 = 8,2 ohms 10 watts MOX resistor

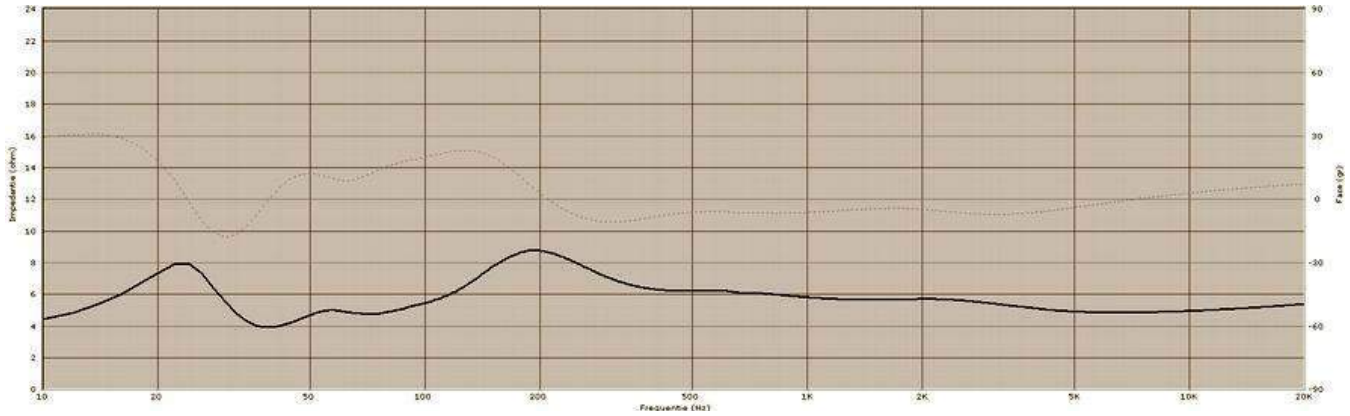
Rz2 = 8,2 + 8,2 ohms 10 watts MOX resistors parallel

Rz3 = 12 ohms 10 watts MOX resistor

Listening impressions and measurements.

The speakers are not small so I advise them to be used in larger listening rooms if you want to unleash their full potential. The best image size is created with listening distances of 4 metres or more otherwise image height gets stretched apart a bit. Like all speakers, give them a few weeks to fully burn-in. Placed on spikes and slightly toed-in the overall balance is extremely coherent, neutral and smooth with an impression of very low colouration. Dynamics can be nearly frightening sometimes when *forte's* seem to appear out of nothing without any feeling of compression. This loudspeaker just gets louder without any change to the tonal character of the system! Imaging is large and spatial with lots of depth. The low-end has lots of weight and is well in balance with the rest of the spectrum, it also seems to go deeper than the measurements would suggest. It's hard to understand that some people consider 7" or 8" drivers to be woofers! Anything smaller than a 12" is a midrange driver! (just kidding). The midrange is open, well defined and very expressive, it lets you really get into the music. The top-end is well-defined and never tiring. For me personally this is my favourite speaker so far!





The measurements show a very smooth overall response (red). Bass-extension is down to about 35Hz and efficiency is good at about 91dB's for 2,83V at 1 meter. The crossover-points are situated near 250Hz and 2kHz and both woofers have a large overlap into the midrange. In the bass you can see the much higher efficiency of the Ciare NDH 15-4S (dark green) compared to the PHL 4531 (light green) of about 7 to 8dB's in the low 35-70Hz octave. The 4dB lift in the bass doesn't seem as audible as it looks and gives the speaker an acoustical foundation that corresponds with the visual image. The impedance plot (black) shows a very smooth overall response with an impedance minimum of 4 ohms at 38Hz. The rest varies mainly between 5 to 6 ohms, this shouldn't perform much of a problem for most amplifiers seeing as the corresponding electrical phase is very smooth staying within the +/-10 degrees range from 200Hz upwards and even in the bass it is within +30/-20 degrees. So your amplifier doesn't need to be very powerful although is it a lot of fun when it is!

Tony Gee, The Netherlands, February 2009