Paper HATT

The big little speaker

The popular HATT mini-monitor range started about six years ago and has seen any variations on the theme. The basic concept has always been the same: a very compact bass-reflex loaded enclosure using a small aluminium woofer and a matching hard dome tweeter. The Paper HATT continues this tradition but on of the major differences is that it now uses a paper-coned woofer.

Aluminium and paper

Using aluminium as a cone material has many advantages, due to the great stiffness the cone moves more like the ideal piston so that the applied music-signal is followed more precise. Also the harmonic distortion is rather low. This is all fine until the stiff material starts to break-up at higher frequencies, this results in sevral major peaks in the output level of the woofer and you need all these correction networks to smooth things out. Paper as a cone material, hardly has any of these break-up problems and therefore has a much smoother frequency roll-off at the top-end. Ideal circumstances for a nice simple crossover, in the Paper HATT even very simple, but more about that later.

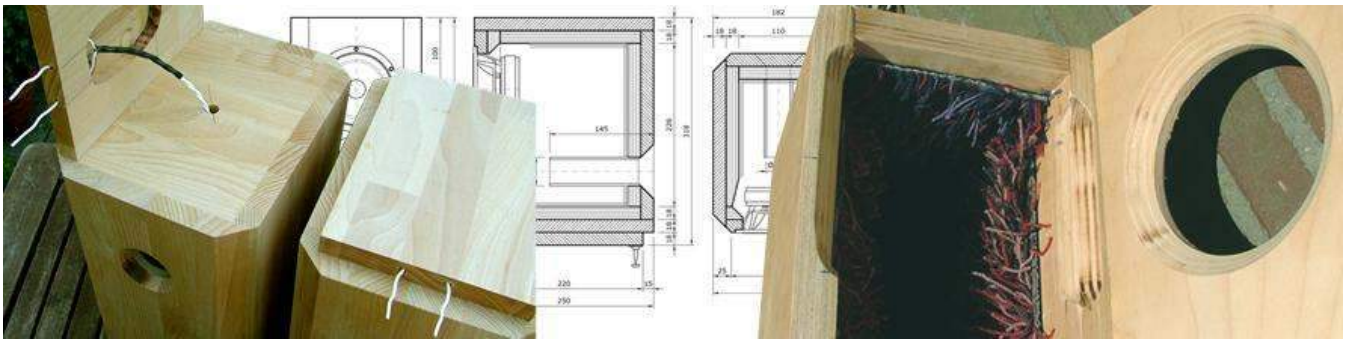
The woofer used here is the Seas CA12RCY - H1152. A small 12cm front-coated paper midwoofer with a cone-area of only 55 squared centimeters. The cone has a natural rubber surround and in the centre is a coated fabric dust-cap. On the rear is a rather large magnet to give the light-weight cone plenty of driving force. A relativly long voice-coil gives a liniare stroke of +/- 6 and an Xmax of +/- 9mm, quite something for such a small woofer. All these components are held together by a stiff moulded chassis with plenty of ventilation. You can even see the voice-coil between the rear suspension and the front pole-plate (so be carefull with dust and other particles!). The magnet also has rear ventilation hole to lower the amount of compression behind the dust-cap, etc. The woofer works in a bass-reflex enclosure of 4 liters netto volume. The rear-firing port is tuned to 63Hz resulting in a -3dB-point around 58Hz.

Titanium and textile

For the Paper HATT you have the choise of two different tweeter types of which only the membrane material differs: the Seas 27TTFNC/GW - H1461 uses a titanium dome and the Seas 27TDFNC/GW - H1462 uses a coated textile dome. Both domes are hung in a wide surround and protected from curious fingers by a metal grille. The H1461 has a small transparant diffusor stuck to the inside of the grille to tailor the top-octave output level and off-axis response. Their voice-coils are wound on aluminium formers and relativly long and flexible lead-out wires are used to allow for some excursion when low crossover-points are used or low order filter-types. The voice-coils work in a low viscosity ferro-fluid. The rear of both tweeters sports a compact but strong neodymium magnetsystem that has an extruded aluminium rear chamber with cooling fins. The rear chamber lowers the resonance frequency and the cooling fins raise thermal power-handling.

Solid wood and plywood

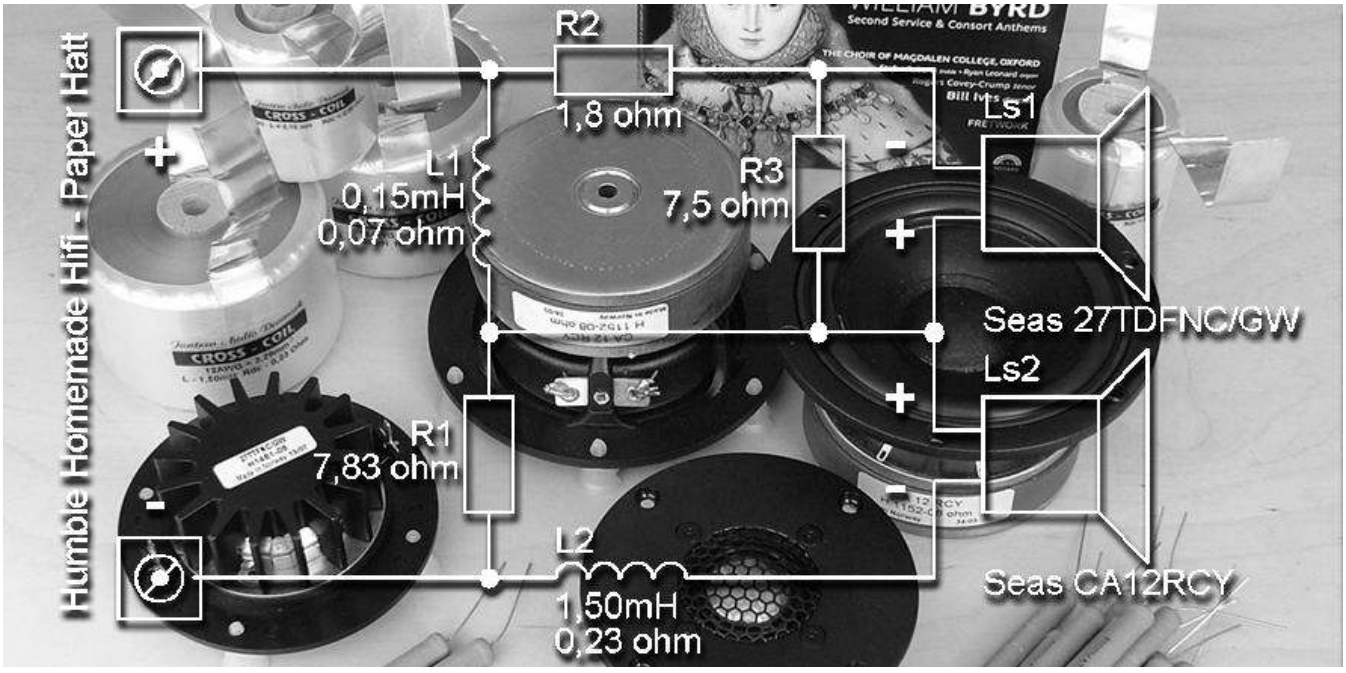
Although the speakers' internal volume is only 4 liters, the cabinets are relativly large and heavy. This is due to the fact that the walls have a thickness of 36mm! The cabinets are made of 12-ply 18mm thick marine-grade baltic-birch plywood and are then covered with 18mm thick solid beech wood panels. Together these two materials form an extremely strong, heavy and dead construction - when finished these speakers weigh 12kg's each! There are several important details to be taken into account when constructing these cabinets: the inside of the woofer opening must be bevelled and the cabinet walls to the left and right of the woofer have a small cut-out to give the woofer enough air to breathe. It is best to make these cut-outs and edges before the cabinet is assembled. The reflex-port on the rear has a large angle to minimize air-flow noise. The ports are made of thick-walled PVC pipe with an internal diameter of 33,6mm's. The total length is 140mm. An nice little detail is the wiring for the 4mm connectors on the back: the plinth underneath the speaker has a channel routed-out through which the silver-coated copper PTFE cables go - neat! A higher resolution drawing is available on request.



All the internal walls, except the baffles, are covered with high-pile carpet (I hope you like the jazzy stuff I used). The carpet is completly glued to the inside of the panels and can also best be done before the cabinet is assembled. For the rest there is no damping material in the cabinet, this is done on purpose to obtain maximum output from the rear port. Subjectivly speaking it also improves the dynamics of the speaker because the Qmc of the cabinet/woofer combination isn't lowered too much. If in your situation you find the bass too strong, then you can always add some wool loosly filling the inside of the cabinet. Don't forget to use dedicated gasket sealing strips between the driver chassis and the wooden cabinet for an air-tight fix.

The world's best capacitor

As mentioned early, one of the design criteria was to use "easy" drivers so that the crossover could be kept as simple as possible. The less parts the better and this gives room to invest in very high-quality components. For this crossover I chose the best capacitor there is: no capacitor! From my extensive listening tests with all types of capacitors, from very basic to very exotic, I have found that even the best high-end capacitors still have a small sonic signature. This can be seen as an advantage and used to give your speaker that certain character you are looking for. I mean, 99% of all loudspeaker-crossover use one or more capacitors but here I took a different approach in creating the necessary high-pass function for the tweeter. The result is that you here the true, clean character of the tweeters.



The Paper HATT uses a series-filter that has only two inductors and a few resistors. Not a single capacitor is used. To show how this works, I will go through each component and explain what happens exactly. Resistors R2 and R3 form an L-pad that lowers the efficiency of the tweeter to match that of the midwoofer, they also create a more constant impedance for the network so that the high-pass function works more according to the book.

Inductor L1 parallel to the tweeter, has the same function as a capacitor in series with the tweeter, namely a first-order high-pass. Low frequencies don't "see" the inductor and therefore pass through the inductor and not through the tweeter. Very important for a correct functioning of this high-pass network is that the Rdc of L1 must be extremely low. The indcutor used here has an Rdc of 0,07 ohms! Were Rdc to be much higher, then the tweeter would also get some low frequencies, drastically lowering power handling and raising the distortion level. To be sure of no microfonic interference in the inductor, I chose a copper-foil type. Inductor L2 is also a copper-foil type for the same reason, here low Rdc is important because both of the inductors are in series with the woofer, so their resistance must be added together. The total Rdc before the woofer is still a nice low 0,30 ohms. The function of L2 is to compensate the baffle-step of the woofer in the narrow cabinet.

Last on the list is resistor R1. This resistor has several functions, first of all it is in series with the tweeter, so it add's to the function of R2+R3 in lowering the output level of the tweeter. Important is that if you decide to choose the 27TDFNC/GW textile tweeter, you must lower the value of R1. This tweeter has a slightly lower output level than the 27TTFNC/GW. If this is not compensated the speaker will sound rather dull. The most important task of R1 is to stop a near short-circuit across the speaker terminals. As there is no capacitor at this position R1 must have a certain minimum value. Were R1 to be infinitly small, then the only resistance your amplifier would see across it's terminals is the Rdc of L1, and that was designed to be as low as possible! A pleasant "bonus" you get with R1 is that, being parallel to the woofer, it flattens the impedance peaks in the bass, creating a

relativly smooth load of about 4 to 5 ohms below the crossover point. Because (together with L1) the resistor R1 is directly across terminals, it must be able to take some power. I used six 10 watt resistors in parallel to give sufficient power handling. Half of the power will still go via L1 - CA12RCY - L2 so there is plenty of headroom.

L1 = 0,15 mH 12AWG copper-foil inductor, R = 0,07 ohms (matched pair less than 1% tolerance)

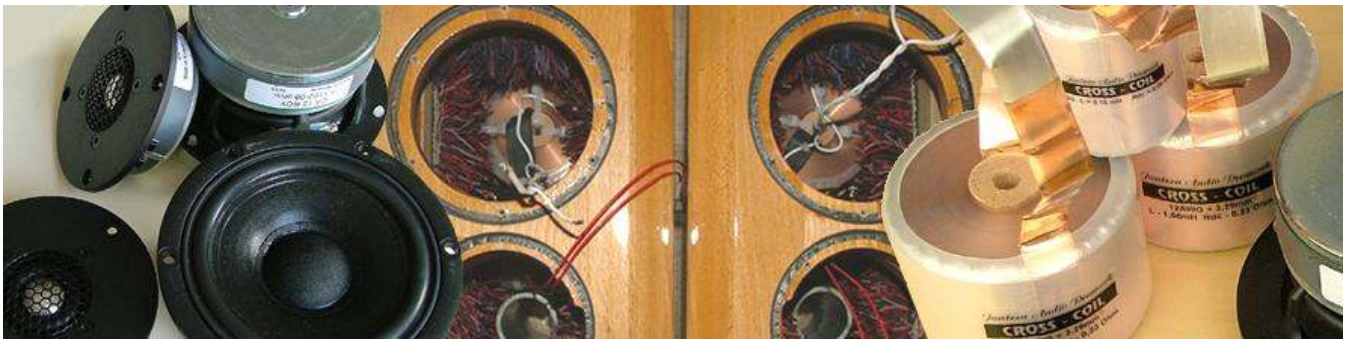
L2 = 1,50 mH 12AWG copper-foil inductor, R = 0,23 ohms (matched pair less than 1% tolerance)

R1 for the 27TTFNC/GW = 7,83 ohms (6x 47 ohms parallel) MOX or better (matched pair less than 1% tolerance)

R1 for the 27TDFNC/GW = 6,50 ohms (6x 39 ohms parallel) MOX or better (matched pair less than 1% tolerance)

R2 = 1,8 ohms / 10 watts MOX or better (matched pair less than 1% tolerance)

R3 = 7,5 ohms (2x 15 ohms parallel) 10 watts MOX or better (matched pair less than 1% tolerance)

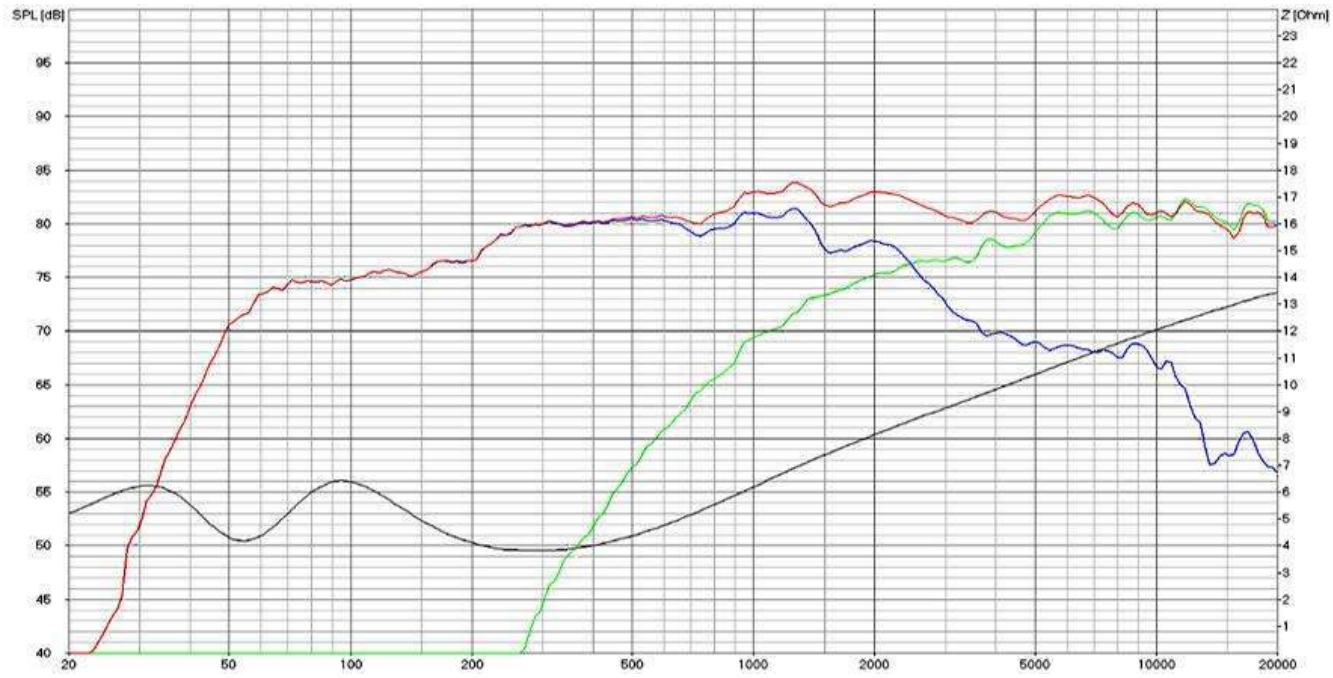


The crossover is fixed to the inside of the rear wall above the reflex-port. It's volume has been taken into account when determining the cabinet/port tuning frequency. A slight alteration in size of crossover components won't make a noticable difference.

Listening impressions and measurements.

The big little speaker indeed! Like all speakers, give them a few weeks to fully burn-in. Once situated on a pair of firm stands with ear-height just between the woofer and tweeter and placed between 50 to 90cm from the rear wall these speakers produce a "big" sound. If you close your eyes, you think you are listening to much larger speakers than these little babies. Their character can best be described as transparant and warm. The low-end has enough weight and is well in balance with the rest of the spectrum. Extreme lows are missing of course but remember we are listening to only 2x 55cm2 of cone area here! The midrange is nicely open, well defined and spatious. All the musicians and vocalists are seperated reasonably realisticly. Even with large choral works (difficult for any speaker) the picture stays intact. The top-end is surpisingly transparant, the metal dome version being more direct, the soft dome more subtle. Every detail in the recording can easily be picked-out, maybe the capacitorless crossover has something to do with that? Anyway, it's a matter of taste I guess which tweeter you choose, personally I prefer the metal dome, it gives me the more "being there" effect.

The measurements show a reasonably smooth overall response (red), seeing that the crossover is very simple it prooves that the drivers are easy to implement. The lower level in the bass-range is due to the fact that the speakers are measured in free-air. In room response is more balanced. On the impedance plot (black) you can easily see that the two peaks centered around the tuning frequency in the bass are nicely smoothed by the combination with resistor R1. The impedance floats around 4 to 6 ohms in the bass and rises gradually to 13,5 ohms at 20kHz. Effieciency is low at about 82dB's, so choose an amplifier that can deliver a bit of current.



Tony Gee, The Netherlands, June 2008