HATT Mk-II

The HATT – A miniature loudspeaker design for in the bedroom (or any other small room). The Mk-II version has minor changes to the crossover.

How small can a loudspeaker go and still have good audiophile performance? How small can a loudspeaker go without having to do any tricks? How small can a loudspeaker go without spending too much money? In this article I hope to have answers for these questions. By the way, the name of the loudspeaker is a sentimental one this time. Our son Tim was born a few weeks ago, so in an emotional moment I decided to call them the **H**umble **A**udio **T**iny **T**im.

Introduction

These loudspeakers were originally designed for a friend who wanted a pair of very small speakers to place in the kitchen. They weren't allowed to cost very much as they were not his main system and he only wanted them so that he could listen to music while doing the washing-up (by the way listening to music while you do the washing-up makes this boring task a little less boring, something I personally could highly recommend). While designing these speakers I got more and more into a sort of "miniature-speaker-mania" because it looked like the result would be much better than I had expected. What started out as a simple "don't spend too much time on them, they're only for the kitchen" design turned out to be a surprisingly nice little speaker. I think I will build a pair for in my bedroom – nice to wake up to in the morning.

The tweeter

The Seas 19TAF/D (H561). A 19mm aluminium dome tweeter with a smooth, extended frequency response. This driver has been around for a few years (note the H-number Seas uses: H561 – at the moment they are at H1100). The chassis is injection moulded in glass fibre reinforced plastic. The diaphragm is made from a thin aluminium sheet and suspended by a soft surround. A diffuser protects the diaphragm and compensates for a slight axial roll off towards 20 kHz. The voice coil is wound on an aluminium voice coil former with ventilating holes that eliminate problems connected with resonances in the internal cavities. The voice coil windings are immersed in magnetic fluid to increase short-term power handling capacity, to reduce the compression at high power levels and to significantly reduce the Q factor. I chose this driver because I wanted the same cone material (aluminium) as the mid-woofer. This unit features a diffuser that enhances dispersion above 10-15 kHz, at 10kHz and 30 degrees off axis it is still the same as the on axis response. At 20kHz and 30 degrees off axis it is only down 5dB's! The faceplate is slightly smaller than the standard tweeters and seeing as I wanted to minimalise things this was also a positive feature.

The tweeter.

The mid-woofer

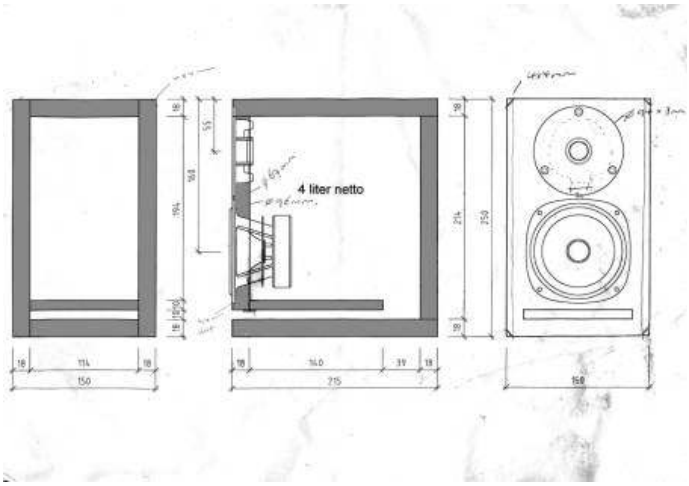
The Seas L11RCY/P. A mini woofer with a stiff and stable injection moulded metal chassis. The stiff, yet light aluminium cone and

the low loss rubber surround show no sign of the familiar 500-1500 Hz cone edge resonance and distortion associated with soft cones. On the other hand, the cone break up modes at higher frequencies call for special attention in the crossover design work but it doesn't break-up until about 10kHz, way above the crossover point. The high temperature voice coil wound on an aluminium voice coil former gives high power handling capacity. A bullet shaped phase plug reduces compression due to temperature variations in the voice coil, avoids resonance problems that would occur in the volume between the dust cap and the pole piece and increases the long-term power handling capacity. An extra large magnet provides relatively high efficiency and low Q. The unit is intended to be used in very small two-way ported systems producing an astonishingly deep bass and a clean, neutral midrange.

The mid-woofer.

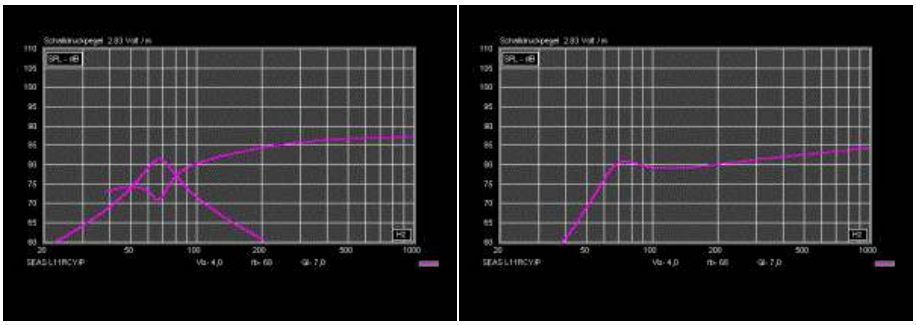
The cabinet

Yet another cabinet made from leftovers! All walls are made of 18mm MDF except the reflex tunnel, which is made of 10mm MDF. Just the standard 6 planks plus one extra for the port. No difficult matrix constructions or sandwich walls seeing as they are so small. Of course there is nothing to stop you doing this if you want to go all extreme.



A higher resolution drawing is available on request.

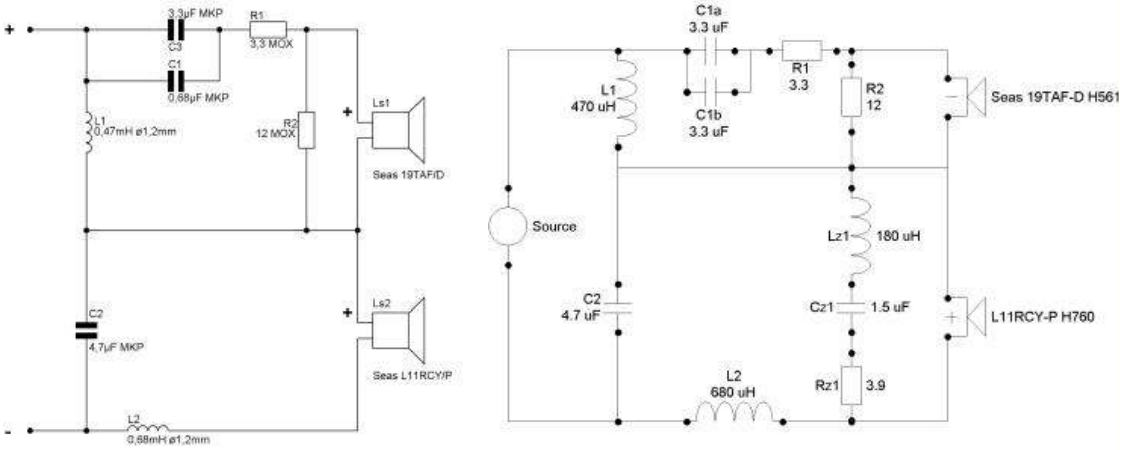
Placing the reflex port in the front baffle is a very wise thing to do. Seeing as it is a two-way system a lot of midrange energy will be coming out of the port. If you place the ports in the rear panel then this energy will arrive delayed compared to the midrange energy coming from the drivers. This will result in some blurring of the stereo image. To save space again I made a slotted port directly under the L11RCY/P. The tunnel is made from a piece of mdf. The inside of all the walls except the baffle are covered with lead bitumen sheets and heavy-duty carpet tiles. The reflex port is kept clear but the top of the reflex tunnel is also covered with lead bitumen and carpet tiles. The carpet tiles have a nice heavy backing that adds mass to the enclosure. 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. A piece of wedge-moulded foam is placed against the rear wall to minimise standing waves. Bonded acetate fibre damping material is rolled up and lightly fills the whole enclosure. 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. The edges of the side panels are routed with 6mm's at 45 degrees for looks and to remove the sharp edges that would cause baffle diffraction problems. The internal volume is only 4 litres and the bass-reflex ports are tuned to 68Hz.The images show the separate output for the woofer and the reflex port as also the summed output. Note in the right image that due to the baffle step losses the efficiency in the bass region is only around 80dB's measured in free field conditions. Placing the speakers against a wall will boost this area and bring it up to the same level as the higher frequencies. The resulting output level will then be about 85dB's.



The port and woofer output.

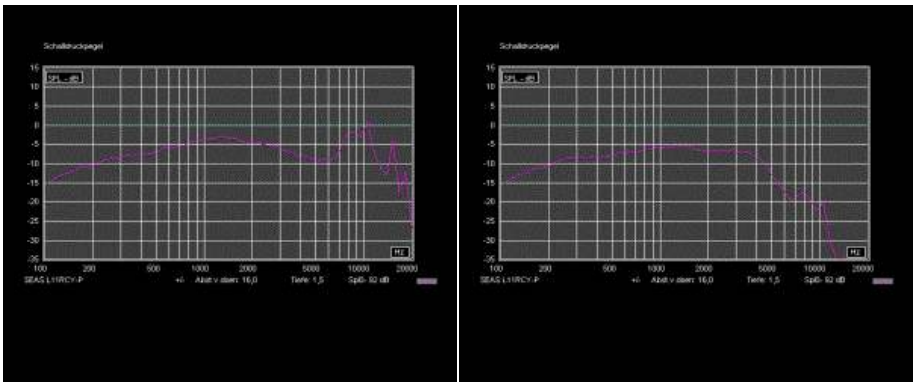
The crossover network

No surprises again here: a series-filter. Due to the use of more accurate measuring and simulation software since the original version came out I have made slight alterations to the crossover. The original crossover is shown on the left, the minor alterations to the crossover for version MK-II on the right. Note that the second parallel capacitor in C1 is now also 3,3uF and a notch filter has been added across the woofer. These alterations result in connecting the tweeter out of phase.

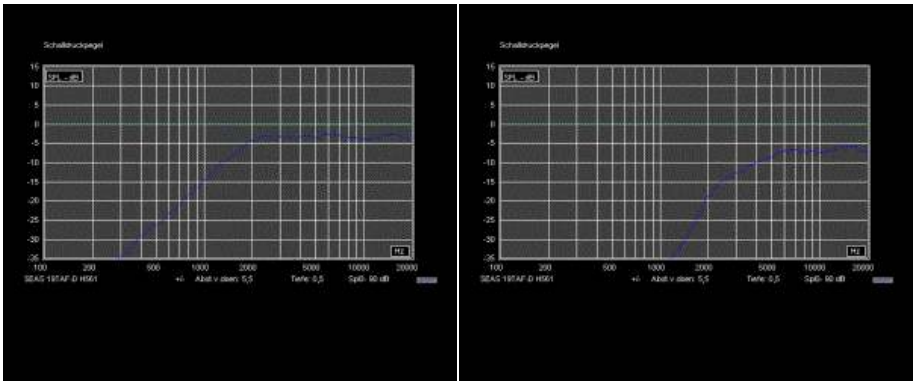


It uses a second-order series-filter. The whole filter is nice and simple using only four active components for two drivers but still giving a crossover with electrical slopes of nearly 15dB's per octave. The only extra components are the resistors to tame the tweeter (the two parallel capacitors are used just to get the correct value) – *later I added the notch filter to smooth out the upper response slightly*.Depending on your equipment and taste the series resistor can vary between 2,7 ohms and 3,9 ohms – I found 3,3 ohms to give the best result. The inductors are air-core type using reasonably thick wire for low Rdc and no saturation and are matched within 1/100 of a millihenry using a LCR meter. The capacitors use metalled polypropylene foil and the metal film resistor is also matched for minimum tolerance. Both units are connected with the same polarity.

The following images show the function of the filter on the individual drivers. What happens to the woofer is especially interesting; there are no special LC networks to cut out the resonance but the roll-off is nice and smooth with only minor low-level peaks around 8-10kHz.



The woofer before and after filtering.



The tweeter before and after filtering.

Wiring and connectors

I kept it simple here; after all they were going to stand in a kitchen. So an internal filter and a single pair of binding posts on the rear, internal wiring is standard 2x 2,5mm OFC. If you want to go all high-end here then there is nothing to stop you using external filters and bi wiring.

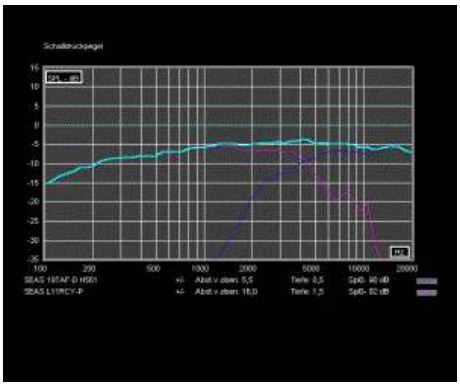
More than just a washing-up speaker

The following remarks are based on the price/quality ratio. A combo using a Scanspeak D2904-9800 tweeter for instance will of

course have more micro detailing but for 4 to 5 times the price. I must say that I was very pleasantly surprised by the quality of these speakers. The sound stage is amazing! It must be to do with the very small baffle because when these speakers are placed free standing on a pair of nice and heavy stands you get a sound stage the size of a large concert hall; very spacious. The downside with this type of positioning is the lack of bass but they were originally designed to be placed close to walls. When they have support from a rear wall it is quite impressive what comes out of these little wonders. The bass is tight and quick with good pace and rhythm as some reviewers would say. Of course you can't expect ultra low bass orgies but the music does have enough body to it. The overall sound is smooth, clear, detailed and revealing without getting harsh. It is an overall speaker with no particular preference for any type of music. But beware; they will reveal any faults in the rest of the system!

The relative output level

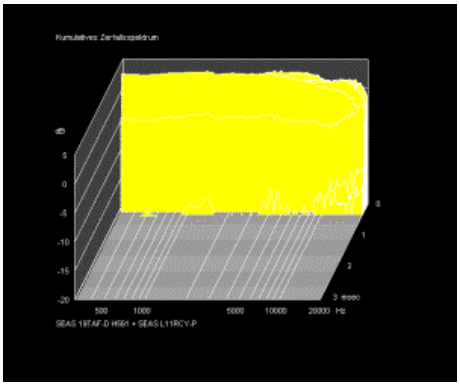
The horizontal scale is 5dB's and the 0dB line is 90dB for 2,83V/1m. It has a relatively flat response with +/-2dB over the whole range with a calculated gradual roll-off towards the bass. The crossover point is quite high at about 4500Hz but this doesn't result in beaming because the L11RCY/P still has good dispersion at this point. The slight hump from 2-9kHz suggests a very detailed and clear sounding loudspeaker. I must stress again that this graph doesn't take into account the lift of the bass and lower mid-range region when placed against a wall or put on a bookshelf. In a small room with rear wall support the response is very even over the whole spectrum.



A nice and smooth response that has a gradual roll-off towards the bass.

The waterfall response

Nothing to complain about here. No visible resonances at all suggesting a very clean sounding loudspeaker.



They don't come much better than this!

Summing things up

If you are looking for a not too expensive and not too large pair of loudspeakers that are easy to build and sound good, then why not build a pair of HATT's? They sound smooth and clean and reveal lots of detail. The bass response is quite remarkable considering the size of the cabinet and woofer. Don't expect ultra deep lows, but a more light-footed and dynamic sounding bass.



Small, but incredibly beautiful!

NOTE: This design is strictly for the home DIY enthusiast and not to be used professionally without my permission!

Tony Gee, The Netherlands

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