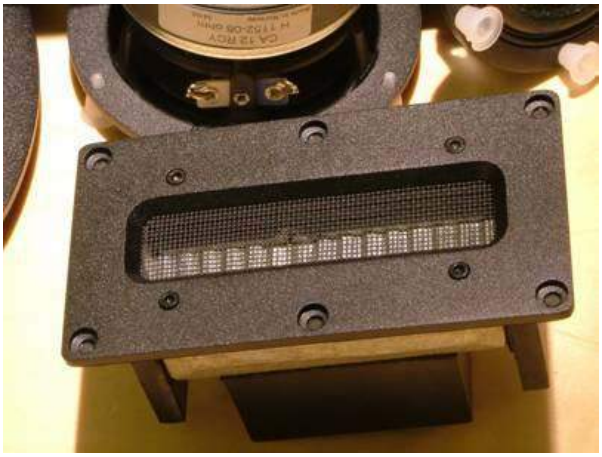
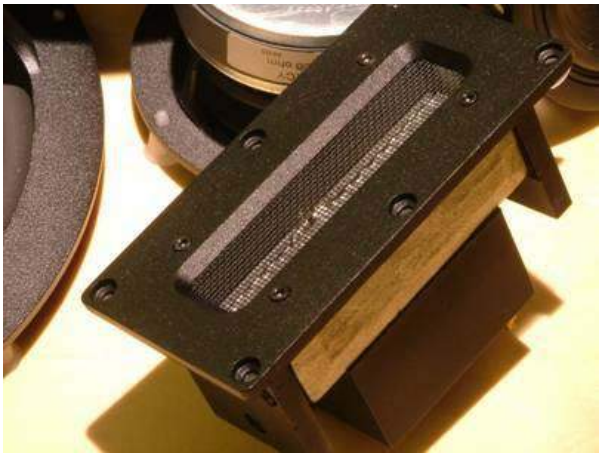
Modulus

Modulus – paper and aluminium at their best!

This loudspeaker combines two completely different types of cabinet loading with completely different types of driver material. The result, after a long path of optimisation, is the best of both worlds.

The tweeter

The Celeritas RB100 a.k.a. Aurum Cantus G3-Si is a pure aluminium ribbon tweeter. It has a very lightweight moving mass made of an aluminium ribbon, giving a very extended frequency response and treble with lots of "air". It uses N45 NdFeB magnet bars either side of the ribbon that also add to its 99dB/W/M high efficiency. The RB100 / G3Si has good wide horizontal dispersion but due to the physical shape of the ribbon it is limited in vertical dispersion, so it is important that the tweeter is at ear height. This may mean that the bass cabinet dimensions may need to be altered to match your listening height.

The mid-woofer

The Seas CA12RCY - H1152 is a bass-midrange driver with a natural rubber surround and hand coated paper cone with coated fabric dust cap to reduce resonances and distortion. The large magnet system forms a symmetrical driving force accomplished through a special coil winding technique for the voice coil giving excellent linearity. A very large magnet system (that I made even larger by adding a second magnet) provides a reasonable efficiency and a low Q. The extremely stiff and stable injection moulded metal basket keeps the critical components in perfect alignment. Large windows in the basket both above and below the spider reduce sound reflection, air flow noise and cavity resonance to a minimum. The extra magnet Seas type H1120 raises the magnet force Bl from 6,35 to 6,85 – nearly 10% more, I had the impression that it made the CA12RCY sound a little more dynamic with a little extra "bite". The acceleration factor grows from an already impressive 1041 to a very nice 1123. Efficiency of the driver also rises a bit by 0,65dB.

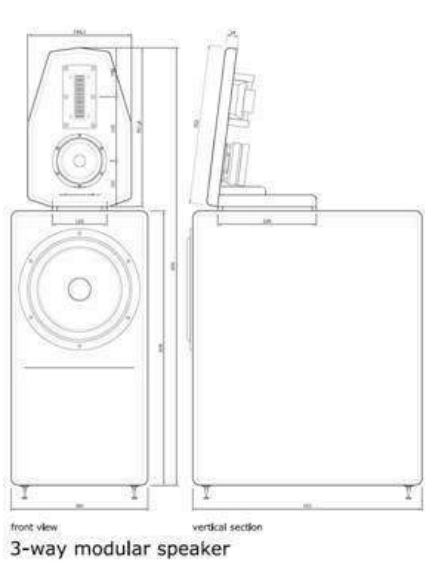

The woofer

The Seas CA26RE4X - H1316 is a 26cm woofer. The classical manually front coated paper cone and matching natural rubber surround produce a smooth response and reduce potential resonance problems. A four-layer voice coil provides a well-behaved roll off characteristic. A large magnet system gives good sensitivity and transient response. An extremely stiff and stable injection moulded metal basket keeps the critical components in perfect alignment. Large windows in the basket both above and below the spider reduce sound reflection, air flow noise and cavity resonance to a minimum.

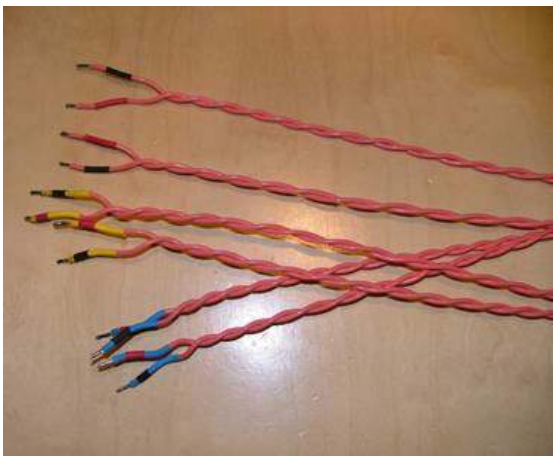

The cabinet inside and out

The cabinets were constructed by Hubert Keller from France and made of thick 22mm mdf covered with an extra layer of 10mm mdf,

bringing the total wall thickness to 32mm. Originally the design incorporated an open-backed midrange enclosure similar to the Focal Audiom designs for example but during the tuning of the system this type of midrange enclosure showed severe standing wave problems that could only be tackled by heavy stuffing of the midrange enclosure. This robbed the system of its dynamic nature. So we decided to go open-baffle. Later on you will see that the open-baffle midrange is very critical in position and amount of damping material (felt in this case) but once done right everything clicks into place and you are rewarded with an extremely open, dynamic and colour-free midrange. The shape of the baffle is a combination of functionality and aesthetics. The baffle sits on top of the woofer enclosure via three spikes. The woofer enclosure is more straightforward closed box of 50 litres with internal bracing. The Q of the woofer section is tuned to 0,58 that is a good compromise between maximum flat response (Qtc=0,707) and best pulse response (Qtc=0,5). The Seas CA26RE4X will work in anything up to about 80 litres, also the height of the woofer enclosure will determine the optimum listening height of the speaker. Ideally the centre of the open-baffle should be at ear height so you are free to change the dimensions of the woofer cabinet to match your situation the best. All dimensions are based on the Fibonacci Numbers 3, 5,8,13,etc. I have found these to be visually pleasing and acoustically ideal for spreading out the standing waves to less critical intervals. The damping material in the woofer enclosure consists of loosely filling the enclosure with bonded acetate fibre like Sonofil. The midrange baffle has a 15mm thick heavy foam layer on the horizontal plate to cut reflections off this section. Furthermore the midrange driver double magnet is covered with a 4-5mm thick layer of felt. All internal wiring is silver-plated oxygen free copper in PTFE.



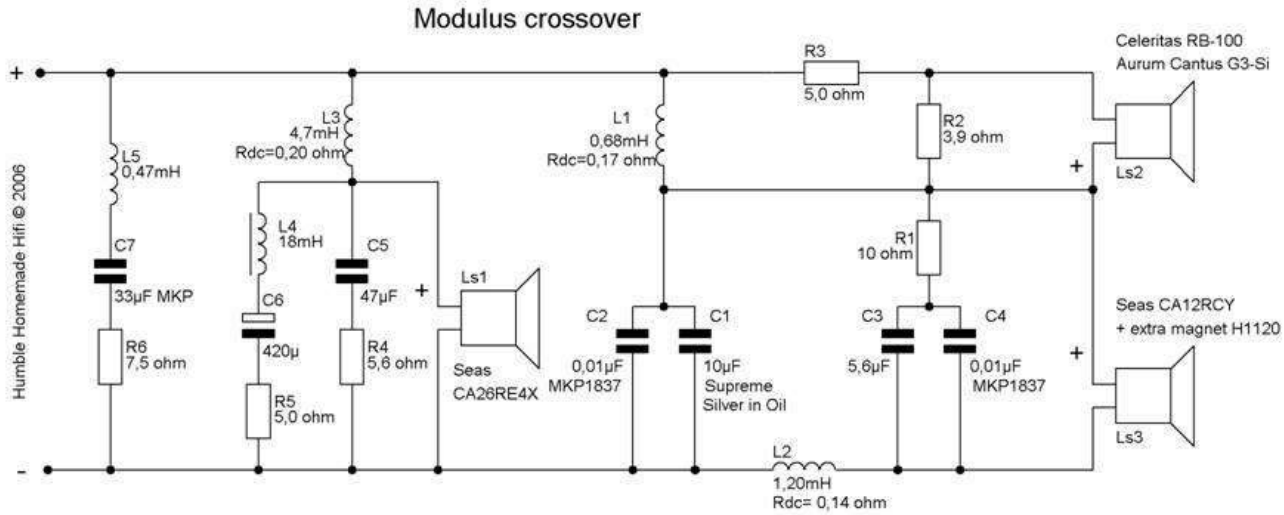
3-way modular speaker



Crossover.

This crossover took a lot of tweaking to get right. The open-baffle midrange produces a lot more midrange energy in the room than a normal closed box even though the on-axis response doesn't suggest so. In the end the crossover turned out to be a relatively simple two-way series crossover with a parallel network for the woofer added creating a 2.5-way system. The woofer section is basically a simple 1st order network with an RC-network to compensate the inductive rise of the woofer voice-coil impedance. Furthermore an LCR-network is added to flatten the impedance peak at Fb so that the 4,7mH inductor will work properly. Finally another LCR-network is placed directly across the input terminals to flatten the overall impedance to make an amplifier friendly load (see impedance curve).

Crossover components:



L1 = 0,68 mH Intertechnik Tritec inductor 3,5 mm wire or Solen Perfect Lay or Goertz CFI 14AWG, R = +/- 0,15 ohms

L2 = 1,20 mH Intertechnik Tritec inductor 3,5 mm wire or Mundorf CFC-10 or Goertz CFI 12AWG, R = +/- 0,15 ohms

L3 = 4,7 mH Intertechnik Torobar inductor, R = 0,20 ohms

L4 = 18 mH ferrite-core inductor, R = 3,5 ohms

L5 = 0,47 mH air-core inductor, R = 0,57 ohms

C1 = 10uF Mundorf M-Cap Supreme Silver/Oil capacitor

C2 = 0,01uF Vishay MKP1837 polypropylene foil capacitor

C3 = 5,6uF Mundorf M-Cap Supreme or Intertechnik Audyn Cap Plus polypropylene foil capacitor (tolerance max 2%)

C4 = 0,01uF Vishay MKP1837 polypropylene foil capacitor

C5 = 47uF standard MKP polypropylene foil capacitor

C6 = 420uF bi-polar capacitor (390uF elco + 33uF MKT parallel)

C7 = 33uF MKP polypropylene foil capacitor

R1 = 10 ohms, 10 watts carbon film resistor

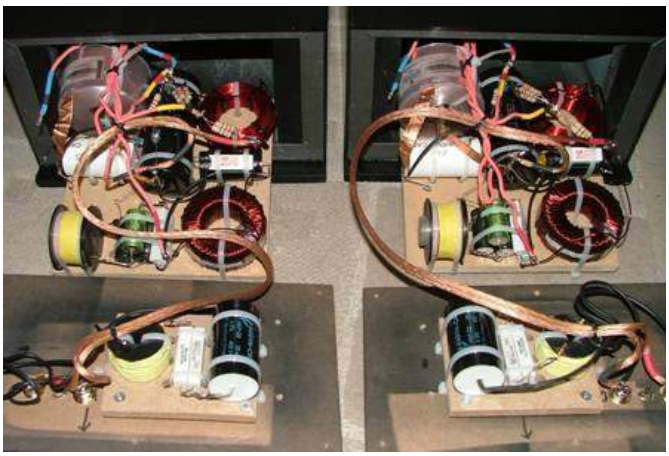
R2 = 3,9 ohms, 10 watts carbon film resistor

R3 = 5,0 ohms (2x 10 ohms parallel), 10 watts carbon film resistor

R4 = 5,6 ohms, 10 watts cement resistor

R5 = 5,0 ohms (2x 10 ohms parallel), 20 watts cement resistor

R6 = 7,5 ohms (2x 15 ohms parallel), 10 watts cement resistor



The crossovers with the separate LCR network mounted on the back panel.

Listening results from the owner:

Here are comments about the speaker made by the current owner; this also includes the last stage of tweaking of the speaker at his house:

"So, as promised, here are my impressions after filter components burn-in: Remember, when we first talked about this project I hoped to get something more dynamical than my present (very good) 2-way kit. Then, you asked me what are my main listening preferences; I answered: dynamic, soundstages, acceleration, details, no fatigue: TARGET IS REACHED for EACH of them, and even MORE: These speakers let me feel that I'm listening to an almost perfect system: what I mean is that all the criterions are at the top BUT all is included in this kind of "oneness" you talked about the series filters; music flows and all the sounds are related ones to the others in a perfect coherency.

You got a very REVEALING speaker, which the first quality is its "PRESENCE". I think this quality is directly related to the absence of box coloration, to the "speed" of the mid-driver and tweeter, to the well dampened bass loading and evidently to the filter design: it's a true CLEARNESS, not an artefact, i.e. the mids aren't "projected"; you got the best of each driver and succeeded to cancel their defects: this is proof of your design mastering. Comparing to my 2-way, there are more details in mids and trebles, tighter bass and transients are amazing. Also: a good sensitivity and almost no trouble when played at high levels. Image and soundstages grown up with the listening level allowing a very realistic musical event. I feel the "oneness" of the sounds particularly in this soundstages-range: it's something new to my ears."

"Two (very slight) weakness that I hope perhaps to reduce with your advices:
- Bass: yes, could be a little stronger and deeper: once again, we have the same preferences...but I know that with these loading volume and driver you couldn't make more in this area. However, bass is tight, uncoloured (no box resonances) and I prefer this than a less damped bass-range. But...do you believe I could "play" with stuffing? If yes, in what way? (I have no experience with closed loadings)
- Uppermid at high listening levels becomes very slightly "howling", BUT ONLY on some cds; Did you try to damp the magnets with some felt or foam, and/or the rear side of the open-baffle? If not, do you believe I should try it, or do you guess this will delete some aeration? Please, don't think I am not fully satisfied about your work, I AM, just am I wondering to make the Modulus the most perfectly adapted to my ears, electronics and room."

This was later followed up by these comments:

"If you are the boss in filtering, I begin to be a boss in FFT (Final Fine-Tuning), ha-ha:
- removed the 2 little pieces of stuffing inside the 2 upper cavities of the bass enclosure, letting the main walls free, as you advised: got slightly more details and spl particularly in bass which, in my room, matches perfectly mids and trebles, without any boominess...and no loose of sub-bass....
- leaned the entire speaker backward with 2 huge cones-feet in front and a doubled nut in back: slightly reduces the amount of upper-trebles (even in my "dead" room).
- removed the felt ring behind the CA12 and replaced with a thin (4-5mm, not more) layer of felt covering the entire ferrite: reduces similarly the mid-emphasis than the felt ring but opens the sound more.
Result: Ah, PERFECTION ?! ha-ha. I modestly advice you to write a few words about this matter on your site, not to say my configuration is the best in different rooms but just say that it's incredible how a (this?) speaker can be depending of a few pieces of stuffing/felt! Worth the effort! When I listen to the Modulus, I say to me: somewhere it's not normal to be able to freely get this sound..."

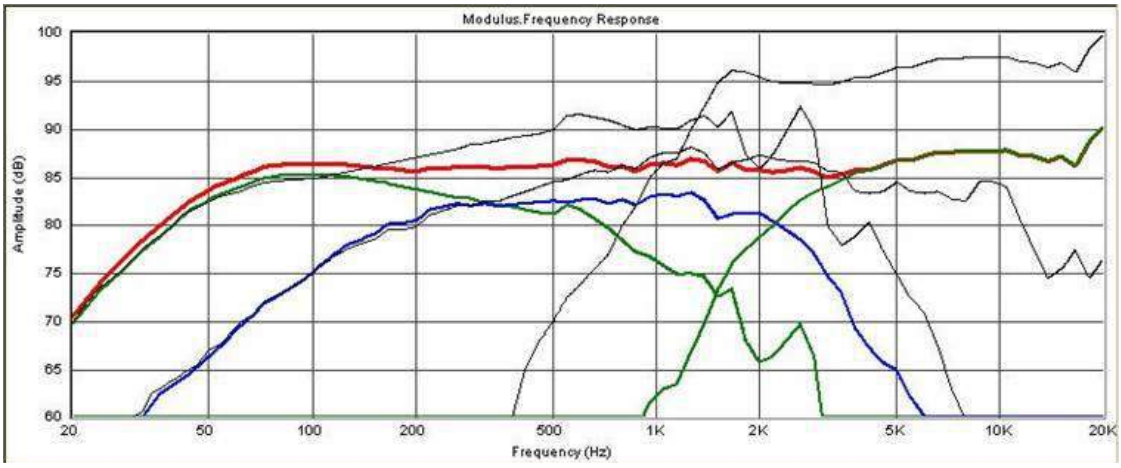
Again a little later another follow up with these comments:

"Yes, I know...never say "final", whatever matter it is, tweaking a Progress (ha-ha) or listening to the Modulus (hum hum). Excuse me please with what follows:
Even if on a few cds the result in term of frequencies balance is perfect, it is not the case on others. After testing a lot of configurations about placement and bass stuffing, I finally arrived to...your last setup, it's to say with all the stuffing you placed inside the bass enclosure: this gives the tighter and less resonant bass. But something wasn't "in place" with some cds, the sound was sometimes really too present, so I played with the rear of the mid-driver: the last setup that gives me satisfaction is the CA12 magnet covered with some felt: the soundstages, aeration, details and dynamics are beautiful. I finally fixed the problem: when I'm listening to cds with a lot of treble, and only with them, the sound becomes to be too harsh: placing more felt rear the mid doesn't really help and eats details.
SO MY MAIN PROBLEM IS THE TREBLES SPL! I guess this can come because I listen relatively close to the speakers in the way to get the best soundstages."

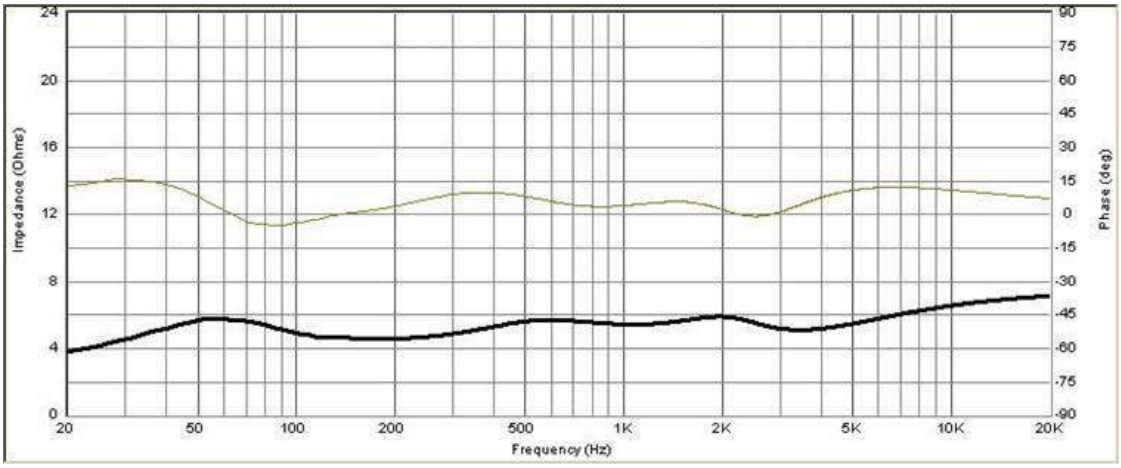
Then finally:

"Thanks again, the added parallel 33ohms works very well with my Tara labs! Quieter on all my cds, without loosing any details or dynamics, a subjective fuller and more detailed bass range but "snaps" remain, perfect with my Rogers, sometimes (very) slightly on the dark side with my SKA. Also an almost greater SOUNDSTAGING !!!. All in all, I'm now REALLY FULLY SATISFIED."

Measurements



Filter function curve 20-20.000Hz; horizontal division 5 dB, unfiltered curves in black. Overall (red) a very smooth output level within +/-1dB with an efficiency of about 86,5dB. Crossover points are centred at about 350Hz and 2200Hz. What can be seen is the large overlap between the woofer (green-left) and midrange (blue) outputs; this is done to compensate the losses at lower frequencies of the open-baffle midrange driver. Also you can see that the high efficiency of the tweeter (green-right) that needed to be brought down to a matching level. These curves are taken near field because the nature of the open-baffle made it too difficult to make any meaningful curves when measured at standard distances. Below you will find the far-field white noise system output.



Impedance curve 20-20.000Hz; horizontal division 2 ohms and corresponding phase horizontal division 15 degrees. The nominal impedance is extremely smooth and ranges from 4 ohms in the bass to 7 ohms in the treble; impedance minimum is 3.9 ohms at 20Hz. The electrical phase is within +/- 15 degrees making a very easy load for most amplifiers.

This raw non-smoothed white noise measurement was taken at 2 metres microphone distance with both speakers playing. The speakers were also 2 metres apart therefore forming an equal sided triangle between the microphone and the two speakers. I believe this to give a more realistic presentation of the "character" of the speaker. Such an approach can never provide "absolute" data about a speaker's performance, because it also incorporates a few minor reflections – even with the gated MLS measuring technique I use

you can’t remove the room completely. However, it can be argued that this technique is actually more meaningful in terms of the actual listening experience. I've measured several speakers this way, and the results invariably show very good correlation between the measured and the subjectively perceived frequency balance of a specific loudspeaker. While the balance is by no means the only important factor in defining a speaker's performance, it is a very significant one. The in-room balance of a given speaker is like a fingerprint—distinct to that loudspeaker, that room, and the sighting therein—and always says much about the overall character of the sonic presentation. Without defining the in-room balance, it's very easy to be "fooled" by minor anomalies that can make the speaker sound artificially attractive (or unattractive). Once the room response is properly defined, it becomes much easier to dig below the surface to discover the underlying qualities – it takes a bit of effort to determine the best measuring position that lets you “see” the speaker and not the room, but its worth it! The bump centred around 850Hz must be due to some reflections because near field measurements didn’t show this emphasis in the midrange; also it wasn’t audible when playing all types of music. The drop above 15kHz is due to the limitations of my measurement system.

Tony Gee, The Netherlands

April 2006