The Monitor

The Monitor, a two-way floor standing speaker taken to the maximum

When driver choice, cabinet construction, crossover components AND budget are at an optimum, what do you get?

The tweeter

The Hiquphon OW-II is a 3/4" soft dome tweeter with outside diameter of ø94 mm, total depth 41,5 mm, with closed chamber of its own, with built-in different chambers for maximum control of resonance phenomenons. It has a black rough colour finish. The OWII is lightly coated. For an analytic sound reproduction and extremely fast-settling step response and sensitivity around 90 dB. Controlled drop off just above 20 kHz. The special exponential semi horn design, of which the dome diaphragm itself is an important part, features an excellent frequency and phase response. It goes like this: As frequency goes higher, only smaller and smaller parts of the dome diaphragm near the voice coil actually moves. So, gradually from being a dome radiator at lower frequencies, the unit turns into a ring radiator at increasing frequency. During this transformation, the dome top itself becomes part of the horn structure at higher frequencies. This technique results in very advanced acoustical control, offering great response linearity, low distortion and impressive phase linearity. The magnet system is driven into a saturated working condition. This means that the highest degree of linearity is achieved. The magnet is over dimensioned making it impossible for the soft magnetic iron parts (top plate and pole piece) to handle all of the magnetic flux, resulting in the fact that the air gap magnetic characteristics turn in to a close-to-linear phenomenon without hysteresis problems, and with very uniform magnetic distribution in the gap. At the same time influence from variations in magnet size is eliminated. Like in the "old-fashioned" turntables, mechanics is essential to the definition and stereo perspective. The tweeters are extremely mechanical solid systems, with heavy housing, well damped reflections, and heavy-duty connectors for joining and soldering the leads. The housing is designed to avoid sharp terminals sticking out. That means you can place the unit on any surface without the risk of scratching your expensive polished speaker front while assembling/testing is done. You could even place the unit on your table in your living room without getting into troubles with your wife. The flange is rounded on the rear side of its edge in order to absorb wooden particles in the 4 mm deep hole in the baffle needed to drop the unit in, so that it can be flush with the baffle surface. Front part and rear part (with the terminals marked + and - for correct polarity) are glued airtight together and cannot be split apart. The unit is air tight from behind, so that the dome cannot be influenced by any modulation from the woofer in the box. Inside Hiquphon use a fibre glass copper plated board with sealed heavy cup terminals, offering heavy soldering joints, to ensure the very best signal path to the voice coil. All connecting joints inside the unit as well as outside provide contact areas much heavier than the connecting wires. Hiquphon recommend 2.5 mm^2 wires as connection to the crossover or the bipolar terminals if used. It maintains stiff and non-vibrating under all circumstances. The voice coil is wound with aluminium wire on an aluminium form, in a very special way developed by Hiquphon, changing the wire turns into an extremely compact mechanical unit that can work up till 120 degrees Celsius without damaging, and can handle very high powers in dynamic peaks.

Dome material has been carefully selected, and coating is applied in several steps, in order to achieve the very best combination of linear SPL response and lowest distortion. Together with linear phase response, crossover design is easily done. Coating the dome

is made in several steps developed during many years, and is in fact one of the secrets of the high quality and production equality from batch to batch. The inner damping is a world of its own! Damping of the cone suspension absorbs travelling waves from the cone, and prevents from returning into the cone making sum and difference tunes and break-ups (distortion!). Venting of the chamber underneath the cone suspension is another important detail, and together with the chamber below the cone itself (which is vented to the special cotton wool damped rear chamber) Hiquphon offers a treble unit, which is top tuned and well damped at the same time. All units leaving Hiquphon are tested at least tree times, two of which are listening tests throughout the entire frequency area. As a special test of the mechanical assembling, they test the unit through a completely crazy dividing network, giving the unit an awful bad time in the area 100 Hz to 3000 Hz to make sure, that there is no rattling or other mechanical noise at all. (This frequency area is the area in which the resonances are most likely to generate undesirable mechanical noise if any mistakes have occurred and consequently will generate higher-order unequal-numbered harmonic distortion).

The mid-woofer

The Audio Technology C-Quenze 18 H 52 17 06 SD is based on the same technology as the Flexunits, but use a solid die cast basket instead of the modular basket used in Flexunits. The best part of energy during development was put into refinement of the performance in the midrange area. All the materials used, were picked to obtain the trustworthiest midrange reproduction. The C-Quenze drivers are extremely fast and move without any dynamic compression due to the mechanical construction. The features such as: SD system, Kapton voice coil former and under hung motor structure are still available in the C-Quenze drivers. Hexacoil voice coil winding technique is used. The high ventilation factor through the centre pole piece, under the rear suspension and the perforation to the voice coil, are naturally kept intact, enabling the moving system to accelerate without any compression. Also frequency response curves in the C-Quenze drivers have been improved, compared to the Flexunits.

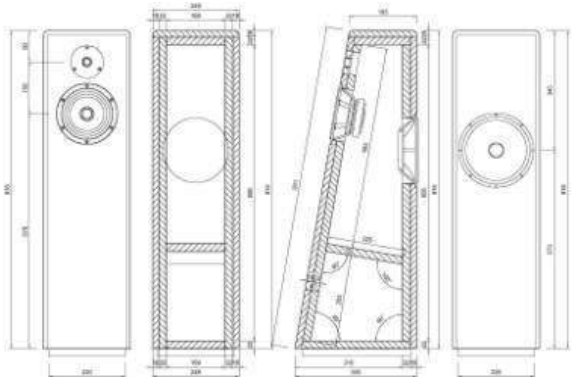
The passive radiator

The Seas SP21R is a 21cm (8") polypropylene cone, low loss rubber surround, injection moulded zinc chassis passive radiator intended for use, as an alternative to the vented port in a bass reflex cabinet, together with an active woofer of similar size or smaller. In many applications the traditional bass reflex port may produce high-speed air noise or even have a poor effect due to a small port area or a large port length. In such cases, a passive radiator may bring about an improvement. Mass has to be added to the cone of the passive radiator in order to obtain the desired resonance frequency in a given cabinet volume. The passive radiator cone is equipped with an M4mm screw to which you can easily fix the added mass. For optimum performance, the passive radiator should be mounted vertically (with horizontal cone axis) this is especially important when a significant additional mass is used. Like an active woofer, a passive radiator also needs time to "burn-in". New from the box its resonance frequency is higher than when it has been used for a while. I had to decrease the added mass after a few months of playing. I used 30mm diameter steel washers; in the end I needed 5 for each radiator. This tunes the cabinet to about 40Hz.

Note the washers attached to the rear of the SP21R.

The cabinet

This monitor was to have as little compromises as possible so the cabinet must be also be built to very high standards. To keep the cabinet from "talking" its form and construction is very rigid and heavy. The cabinet walls are made of two different layers with a total thickness of 40mm. The inside box is made of 22mm mdf covered on the outside with a layer of 18mm hard wood. Inside there is an angled partition to separate the woofer volume from the crossover compartment. Due to the angled front baffle the only parallel walls are the sidewalls. All walls internally are covered with 4mm bitumen sheets to add even more mass and reduce vibrations. Furthermore the crossover compartment is filled (through a removable base-plate) with dry sand after the crossover is mounted, also to add mass and reduce vibrations to an absolute minimum – the sand really helps to get even deeper and tighter bass. Damping material consists of wedge-moulded foam inside the top, bottom and sidewalls. The inside of the baffle and rear wall are kept free.



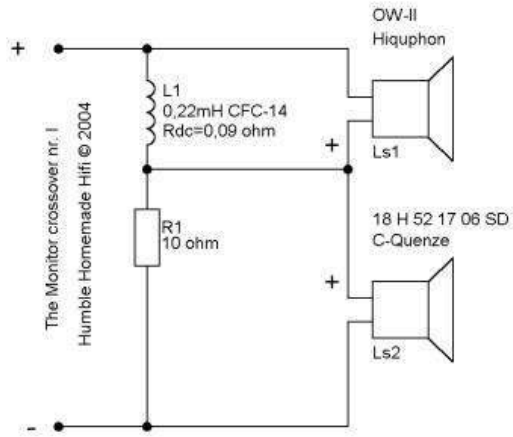
A higher resolution drawing available on request.


Driver cutouts front and back.

Crossovers and listening.

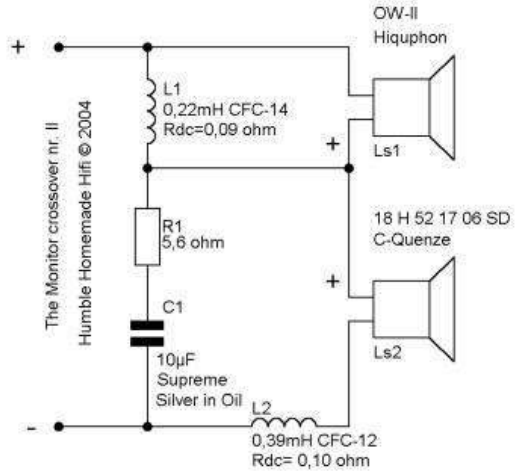
Designing a crossover for the C-Quenze and Hiquphon drivers was very easy and at the same time very difficult. Because these two drivers have such smooth frequency curves and low voice-coil inductance nearly every crossover will work with them – the difficult part is which one sounds the best? So in the end I designed three different crossovers.

Crossover nr.1 is an exercise at how to make the most simple crossover possible: the only filtering component is the small inductor parallel to the tweeter, this works as a high-pass for the tweeter and a minor low-pass for the woofer, it only smoothes the woofers little rise around 5kHz, so basically the woofer is running "full-range". The last two octaves are then supplemented by the tweeter. The 10 ohm resistor parallel to the woofer acts as damping component for the tweeter output but its main reason is to stop a short-circuit across the input terminals, without it the amplifier would only see the Rdc of the inductor as the load and switch into protection mode (if your amp has that feature!). This crossover sounds the most open and spacious of all the crossovers; you nearly get the "full-range-driver-with-super-tweeter-effect" due to the minimalist filter component approach. It is also the most dynamic and efficient version. Downside is the speaker can sound a little thin when placed freestanding. To add body to the music this design must be placed close to a rear wall with just a few centimetres free to let the passive radiator breathe.



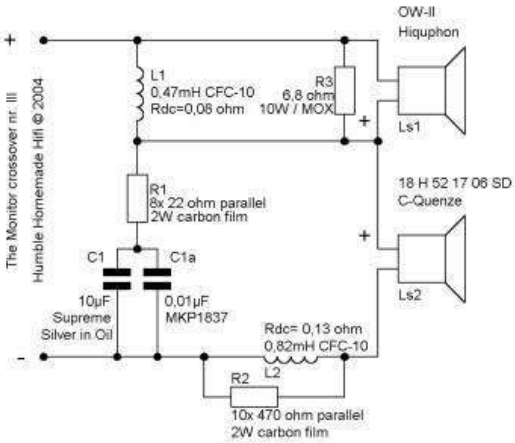
Crossover nr. 1.

Crossover nr. 2 is an attempt at still trying to let the C-Quenze do most of the work to maintain the open and spacious effect but at the same time "tame" the speaker by adding a little baffle-step compensation by means of a second inductor and adding some more tweeter protection. This design must also be placed close to a rear wall to sound well balanced and add some body but is less critical towards bad recordings than nr.1



Crossover nr. 2.

Crossover nr. 3 finally takes a more standard approach. Fortunately the C-Quenze midwoofer has such a low voice-coil inductance (only 0,13mH) that a Zobel network directly parallel to the woofer can be left out – the less components the better in my opinion. Compared to crossover nr. 2 a little more baffle step compensation is added by means of the 0,82mH inductor so the speaker will now sound best freestanding. The 47 ohms parallel to this inductor is to keep a steady 6dB/octave acoustic roll-off even well above fx. Also the crossover point is lowered from about 5500Hz to 3500Hz to give a more even off-axis response. All this results in a very even sounding speaker with a nice clear midrange. The treble has a silky smoothness to it and is also very revealing at the same time. The speaker easily lets you hear the difference between a Stratocaster and a Telecaster. Bass is tight and reasonably deep – the passive radiator produces a nice clean "thump" when you put your ear close to them. Imaging is larger than you would expect from the physical size of the speakers, quite wide and placed in a large area around the speakers. The angled baffle and simple crossover must contribute to this. To increase the tweeter level in crossover nr. 3 you should increase the value of resistor R3. Making it 33 ohms should give the tweeter about 2dB's extra level. You may need to experiment a bit for the exact value. Keep doubling the value, so try: 15 / 33 / 68 / no resistor. Tune to taste!



Crossover nr. 3.

Crossover components:

L1 = 0,47 mH Intertechnik Tritec inductor 3,5 mm wire, R = 0,09 ohms or Mundorf CFC10, R = 0,08 ohms

L2 = 0,82 mH Intertechnik Tritec inductor 3,5 mm wire, R = 0,12 ohms or Mundorf CFC10, R = 0,13 ohms

C1 = 10uF Intertechnik Audyn Cap Plus or Mundorf M-Cap Supreme polypropylene foil capacitor

C1a = 0,01uF Vishay MKP1837 polypropylene foil capacitor

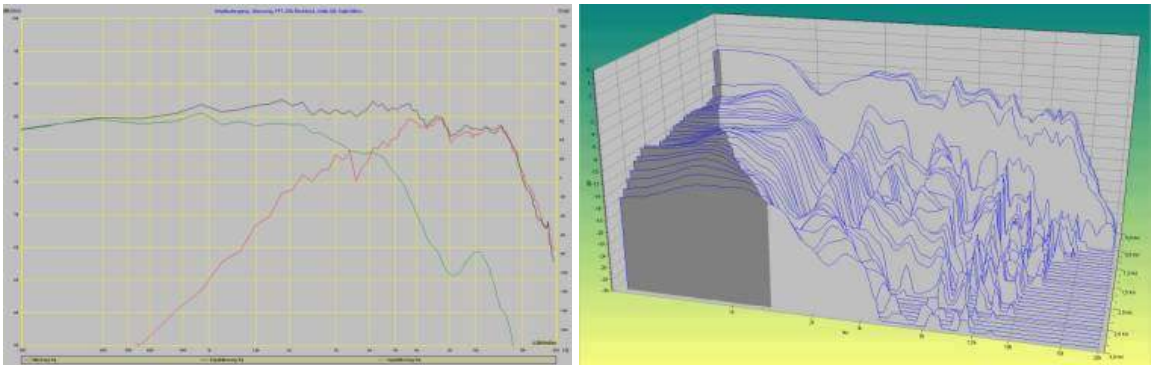
R1 = 2,75 ohms - 8x 22 ohms / 2 watts carbon film resistor parallel

R2 = 47 ohms - 10x 470 ohms / 2 watts carbon film resistor parallel

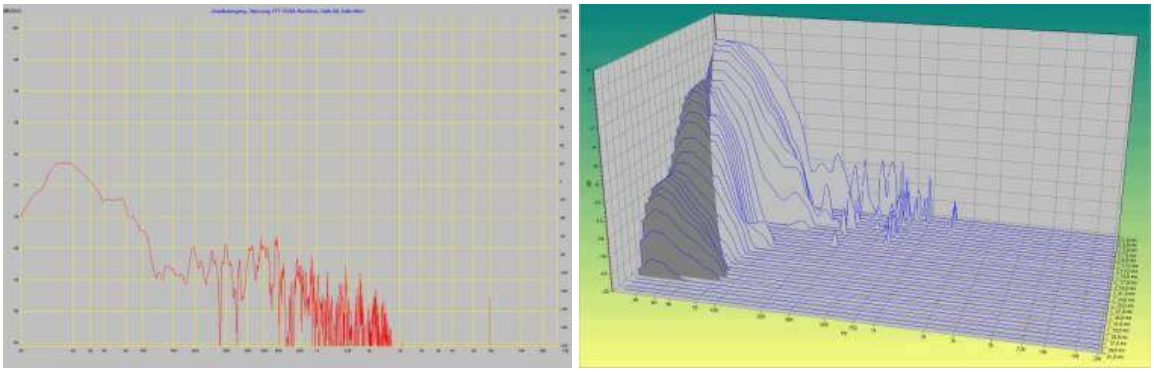
R3 = 6,8 ohms , 10 watts metal film resistor (tune the value to personal taste and system matching)

Because all three crossovers are so simple don't keep a tight budget when choosing the crossover components – the drivers are worth it!

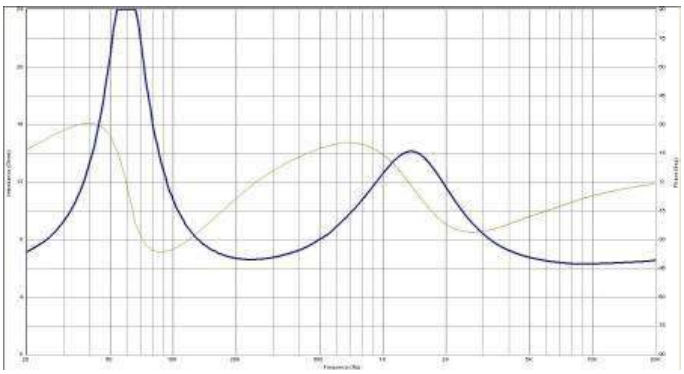
Measurements



Overall output level 200-20.000Hz; horizontal division 5dB and waterfall spectrum horizontal division 2dB.



Passive radiator output level 20-20.000Hz; horizontal division 5dB and corresponding waterfall spectrum.



Impedance curve 20-20.000Hz; horizontal division 2 ohms and corresponding phase horizontal division 15 degrees.

These measurements were 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 siting 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 overall response is smooth within about +/-2dB in the critical mid-band. The crossover point between the woofer and tweeter can be seen at about 3500Hz. The top end roll-off is due to measuring at this distance, when the microphone is placed at the standard 1 metre (or less) distance it is flat to 15kHz, the drop above 15kHz is due to the limitations of my soundcard. The waterfall plot shows a bit of "noise", this is the downside of measuring further away, the closer you get with the mic, the lower the "noise" gets. The measurements of the passive radiator were done directly in front of the radiators dust-cap. Here you can clearly see the advantages of a passive radiator – all the higher frequency trash is at a much lower level than with a reflex port and there is no port harmonic resonance peak (compare these measurements with those of the USB for example). The impdance shows a very amplifier friendly load.

  *Front and rear view.*

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

Tony Gee, The Netherlands

October 2004; updated December 2010 (tweeter level adjustment)