

Calpamos



DESCRIPTION

Two-way, bass-reflex loudspeaker with 15-inch coated paper cone midwoofer + 2-inch titanium compression driver + bi-radial horn.

SPECIFICATIONS

Sensitivity • 93 dB / 2,83 volts
Impedance • 8 ohms nominal
Frequency response • 37 - 20.000 Hz (-3dB) / 33 - 22.000Hz (-6dB)
Crossover frequency • 650Hz / 12dB (2nd order parallel crossover)
Power rating • circa 200 watts RMS
Dimensions (W x H x D) • 486 x 900 x 600mm (without stand)
Weight (finished product) • circa 75kg each

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The loudspeaker kit contains all the components you need, even small items such as black screws for mounting the drivers, gasket sealing tape, etc. The only thing you need to obtain separately is the wood for the cabinets. The vibrodamping panels are NOT supplied with the kit due to their weight. The damping-panels can be ordered on request. The large, hard-wired crossovers come pre-assembled, matched and tested. The price for the Calpamos DIY loudspeaker kit is EUR. 1.390,- each / EUR. 2.780,- per pair.

INTRODUCTION

There are some stubborn misconceptions out there in loudspeaker land, one of them being about the use of pro drivers in domestic hifi systems. I would therefore like to begin this article by saying that the Calpamos is not a PA loudspeaker. It is a high quality two-way hifi loudspeaker. Just because it uses pro drivers does not mean that it is designed to be used in a club or at live concerts. PA loudspeakers have to meet totally different criteria than hifi loudspeakers. Most PA loudspeakers are designed to play as loud as possible, handle very high amounts of power and be very compact. Sound quality usually comes last. With the Calpamos sound quality comes first. Things like power handling and extreme SPL's are not an issue anyway, the Calpamos can play louder than "normal" hifi loudspeakers and with 200 watts power handling it should be more than sufficient for use in any normal sized living room. The fun thing about using pro drivers for domestic hifi is the expressive ease in which they produce music. But for the best results, you can't use just any pro drivers, there are several parameters that have to be taken into account when deciding which drivers are best suited for high fidelity music reproduction.

PRO DRIVERS

As stated, the Calpamos is a two-way loudspeaker. It uses a 15-inch midwoofer in combination with a 2-inch compression driver that is coupled to a bi-radial horn. When choosing suitable pro drivers for a domestic hifi loudspeaker there are a few parameters that have to be taken into consideration. In regards to woofers and midwoofers we are looking for a driver that has low mechanical losses, low moving mass and a low resonance frequency. Low mechanical losses are important when playing music at low sound levels. If the losses are too high you get a speaker that doesn't "open up" unless it is played loudly. Then there is a low moving mass to take into account. I have found that a relatively low moving mass contributes to good articulation in the midrange - vital for a high quality two-way loudspeaker. There is no need for thick, heavy cones here - we are not building a subwoofer! And of course a low resonance frequency is essential for decent bass reproduction. For the Calpamos I wanted to use drivers from [Faital Pro](#) of Italy, they make good drivers at a very reasonable price. Looking at their portfolio and selecting the total of eleven 15-inch woofers I first did the most easy selection by setting the resonance frequency to a maximum of 35Hz. That left me with three woofers to choose from, namely the 15PR400, the 15FH500 and the 15FH510.



Faital Pro 15PR400



Faital Pro 15FH500



Faital Pro 15FH510

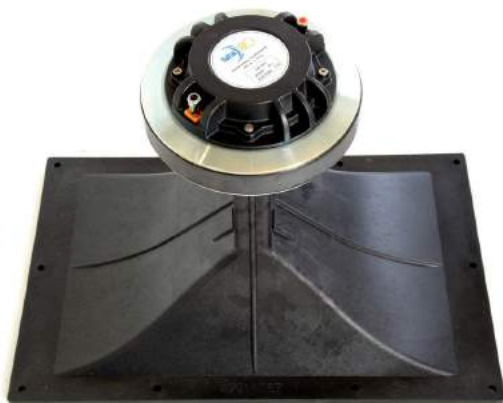
The 15FH500 and 15FH510 both have a relatively high moving mass Mms of 104 and 108 grammes respectively. The Mms of the 15PR400 is only 85,2 grammes. The 500 series woofers do have stronger magnets (higher BL) and stiffer suspension (lower Cms) to compensate for the higher moving mass but I am looking for an agile sports car here, not a heavy muscle car. Think Donkervoort D8 instead of Dodge Challenger (no offense to any muscle car owners). If you calculate the acceleration factor of the three midwoofers (divide BL by Mms) then the 15PR400 has the best acceleration factor even though it has the "weakest" magnet of the three.

One way of checking if a driver has low mechanical losses is to look at the impedance peak at the resonance frequency. If it is low and wide then the driver has high mechanical losses, if it shows a high and narrow, sharp spike, then we are looking at a woofer with low mechanical losses. All three of these Faital Pro 15-inch midwoofers have a 3-inch voice coil with an Re of 5,1 ohms but when we look at the impedance peak at free air resonance Fs, we see that both the 15FH500 and 15FH510 are peaking at around 87 ohms where as the 15PR400 has a nice sharp impedance peak of about double that value at 170 ohms. To me an impedance curve says more than a thousand words ;-) So the 15PR400 it will be.

The Faital Pro 15PR400 midwoofer has an impregnated, light-weight paper cone that is driven by a 3-inch / 77mm voice coil. The voice coil former is made from glass fibre resulting in low losses inside the magnetic field. This is essential when maintaining detail at low SPL's. Further high-lights are a light-weight neodymium magnet, low moving mass and low voice coil inductance. All these parameters are important when looking for high quality, smooth and expressive midrange. And last but not least a low resonance frequency of 35Hz in combination with a Qts of 0,32 are ideal for good bass response in a not too large cabinet. If you are only used to "normal" hifi loudspeakers, 35Hz might not seem that low for a woofer of this size, but trust me, 35Hz from a 15-inch midwoofer sounds totally different to 35Hz from a 7-inch midwoofer. Size does matter!



The tweeter is the Faital Pro HF-201 with a light weight 74mm titanium dome that is "compressed" to a 50mm / 2-inch throat (hence the term compression driver) that has a 36 degree conical exit angle that forms an ideal match with the bi-radial horn. It also uses a low-loss voice coil former, in this case it is made from Kapton. For a tweeter, the HF-201 is reasonably heavy with its massive ferrite magnet that is 170mm in diameter. The magnet alone is thus the same size as most "normal" hifi woofer's overall size. Weighing in at 4,6kg's (over 10lb's) it actually weighs more than, for example, Scan-Speak's 26W/8867T00 10-inch woofer that "only" weighs 3,7kg's. So I guess you could say that everything in the Calpamos is scaled up.



The horn used in the Calpamos is made by P-Audio from Thailand. The P-Audio PH-2380 is based on the legendary [JBL 2380A](#) flat

front bi-radial horn. The PH-2380 is a 2 inch (50 mm) throat horizontal format high frequency horn with a 443 x 280mm mouth. The horizontal coverage angle is 90 degrees and the vertical coverage is 40 degrees. P-Audio give a cut-off frequency of 400Hz, I am running it from 650Hz. The PH-2380 is constructed of high impact ABS with a glass fibre filling to insure additional stability and structural rigidity. That is no luxury when hanging 4,6kg's of tweeter on the back ;-)



THE CABINET

The cabinets that house the components have been designed to be easy to build. Instead of using massive internal bracings and extremely thick panels, I choose to use 18mm / 13 ply baltic birch plywood that is internally strengthened with 44 x 44mm solid pine timber. You will need a whole sheet of 1250 x 2500mm plywood for each cabinet. One sheet weighs roughly 40 kg's - you will need two people to carry it. The divisions created by the 44 x 44mm timber are chosen in such a way that they are not multiples of each other. This way, any panel resonances that could occur will not be amplified. Better to have a few low-level resonances than only one or two that are much higher in magnitude. Keeping the noise-floor as low as possible, I think audiophiles call it. And yes, I probably could have cut the panels from 30 or 40mm birch plywood but I probably would have broken my back in the process. With a total finished loudspeaker weight of about 75kg's per loudspeaker there is plenty of mass behind these drivers.



These self explanatory photographs taken during the build of the cabinets should give you a good idea of how the cabinets are put together. Not visible in these images is a 160 x 450 x 18mm plywood bracing panel that joins the two side panels together. Also the round cut-out for the midwoofer is glued to the inside of the rear wall to create a little more stability and add a bit of mass. Please check the CAD-drawing for this, at the top of this page you will find a link to the pdf-drawing of the cabinets with all details

and measurements. I choose to construct the cabinets using normal white PVA wood glue and wood screws. This method is a quick way of putting cabinets together and is the only way to do it if you don't have a huge collection of large clamps. Seeing that I was going to veneer the cabinets anyway, I didn't have to worry about sunken screw-heads becoming visible in the paintwork. That said, it is still very important to fill all screw-heads and any other surface irregularities with two component epoxy filler before you veneer the cabinets. Standard filler shrinks after a while, leaving visible dents in the veneer.

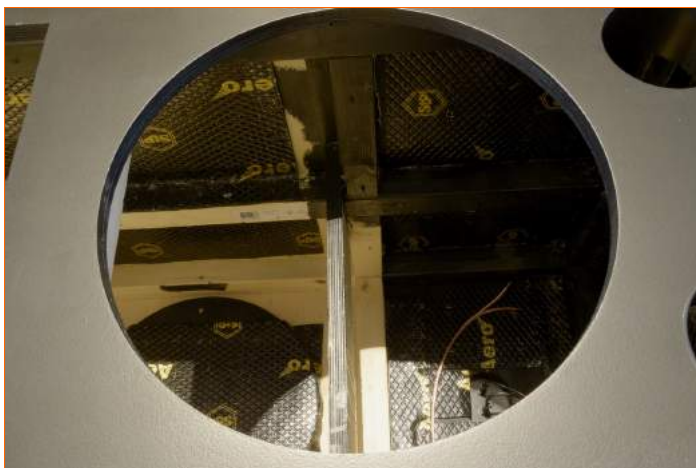


To give a sort of "vintage" look to these speakers I choose to use Palissander veneer by SaRaiFo (Save the Rain Forest). Using real tropical wood veneer is a no-no, the veneer made by SaRaiFo is made from normal quick growing trees such as poplar and lime and then treated and coloured to look like exotic wood. So it feels like real wood (because it is) and looks like something exotic. Nice things also is that it is a lot cheaper than exotic woods, I spent roughly sixty euro's on over 3 square meters of veneer which was just enough for both cabinets - note that the front and rear are not veneered. I painted these black before I veneered the cabinets. I also painted the lower section of the inside of the cabinets black because part of it is visible through the two PVC ports. After the cabinets were veneered and sanded, the entire cabinet including the black painted panels were given three layers of clear, matte varnish that were finely sanded between each layer.

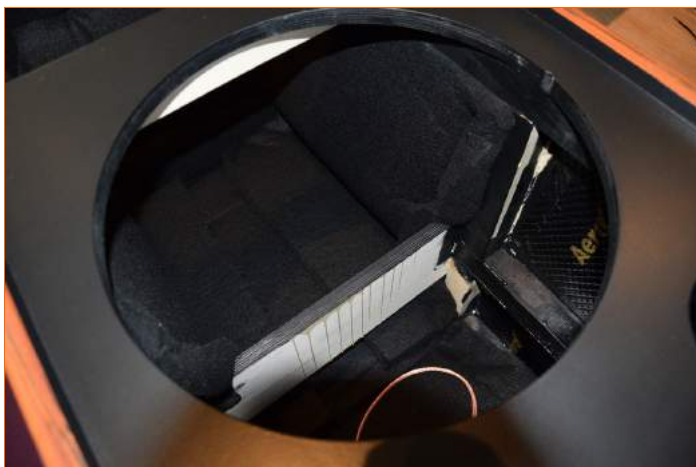
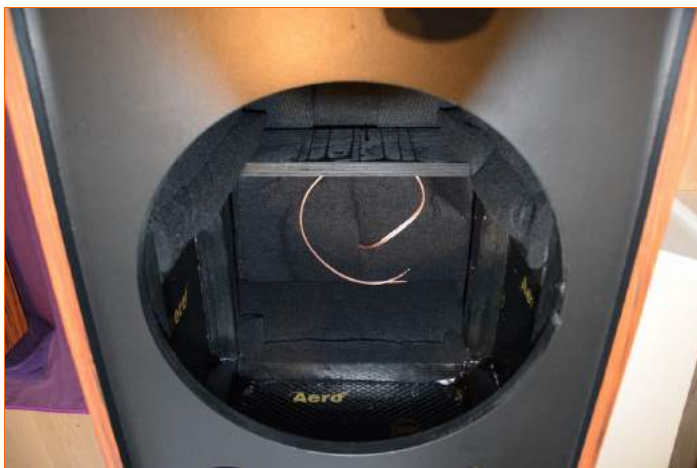


The inside of the cabinet is lined with 4mm thick bitumous vibration damping panels. Due to the high weight of these panels (and therefore high shipping-costs), they are not included as part of the standard kit but can be supplied if they are not available where you live. I used Standartplast STP Aero Bomb but other products such as CTK Vibrodamping, Silent Coat Vibrodamping or Dynamat Xtreme are equally effective. Apply the damping panels to all internal surfaces except the baffle. It doesn't matter if a few centimeters along the edges of each surface are not covered. The damping panels are self adhesive but I would advise to take extra measures to make sure they stay stuck in place for years to come. First of all, the inside surfaces of the cabinets must be dust and grease free. Then the panels can either be glued using vinyl glue as well as their own adhesive layer. Or you can stick the panels as they are and then staple them to the cabinets for extra strength. I chose to do the latter with the help of an electric

staple gun.



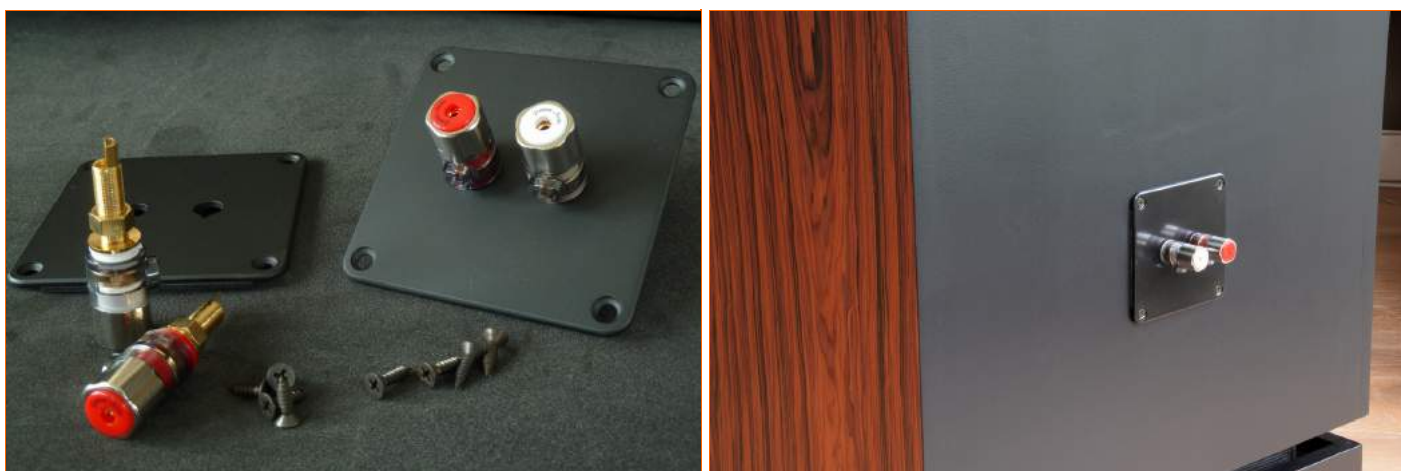
The soft damping material used in the Calpamos consists of 50mm thick, black polyester fibre acoustic damping sheets. Each sheet is 1000 x 1200mm in size and one whole sheet is needed per loudspeaker cabinet. The damping material covers all internal area's except for the lower part of the side walls near the woofer and also the bottom surface is left free from this soft damping material.



To create an air-tight seal, gasket sealing tape is applied to the rear of the midwoofer chassis and the rear of the horn. The binding-post plates have their own seal on the rear. All these small components such as screws and gasket sealing tape are also supplied with the loudspeaker kit.

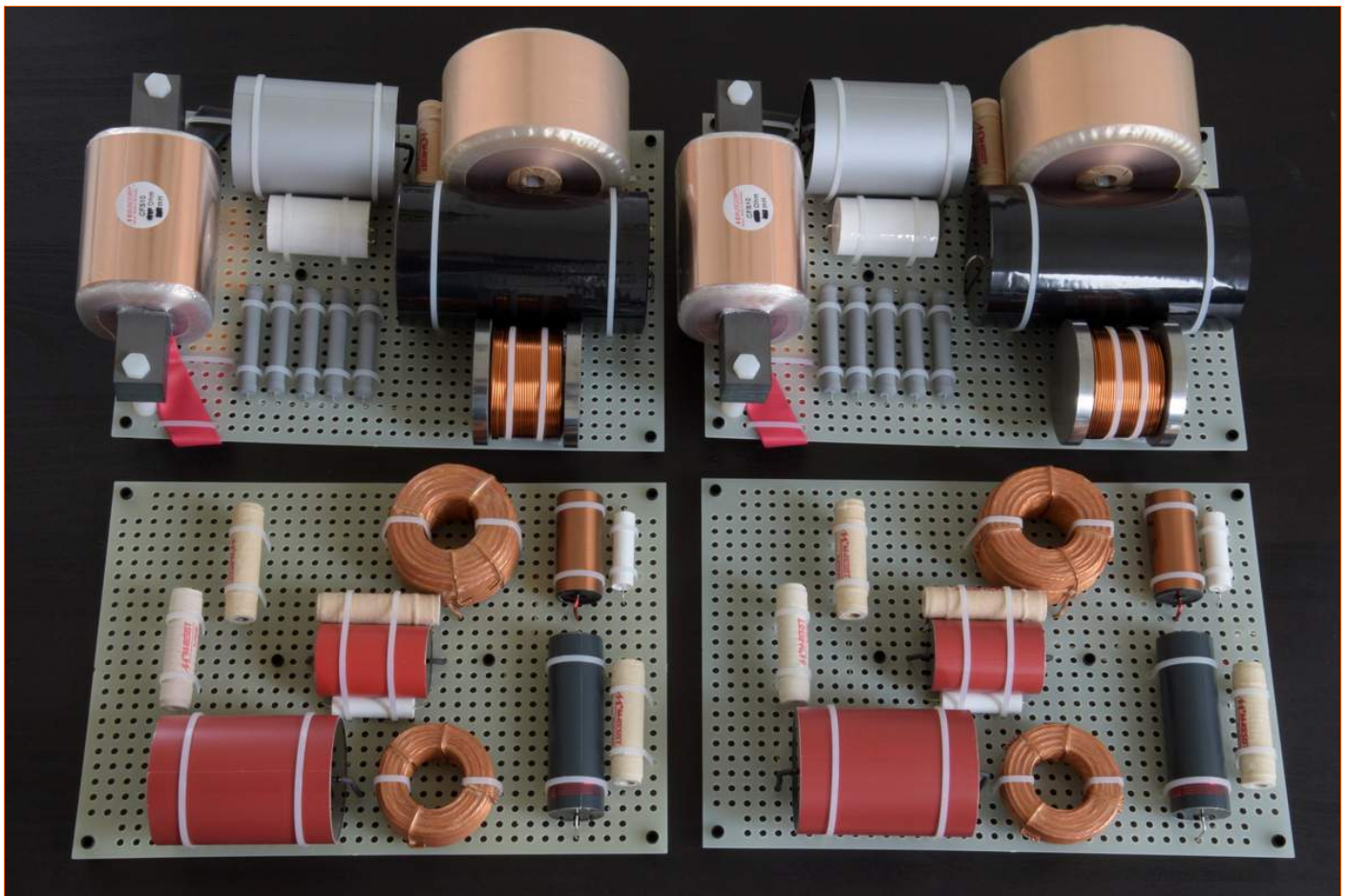


The standard kit comes with single wiring terminals, on request and for a small surcharge bi-wiring terminals can be supplied.



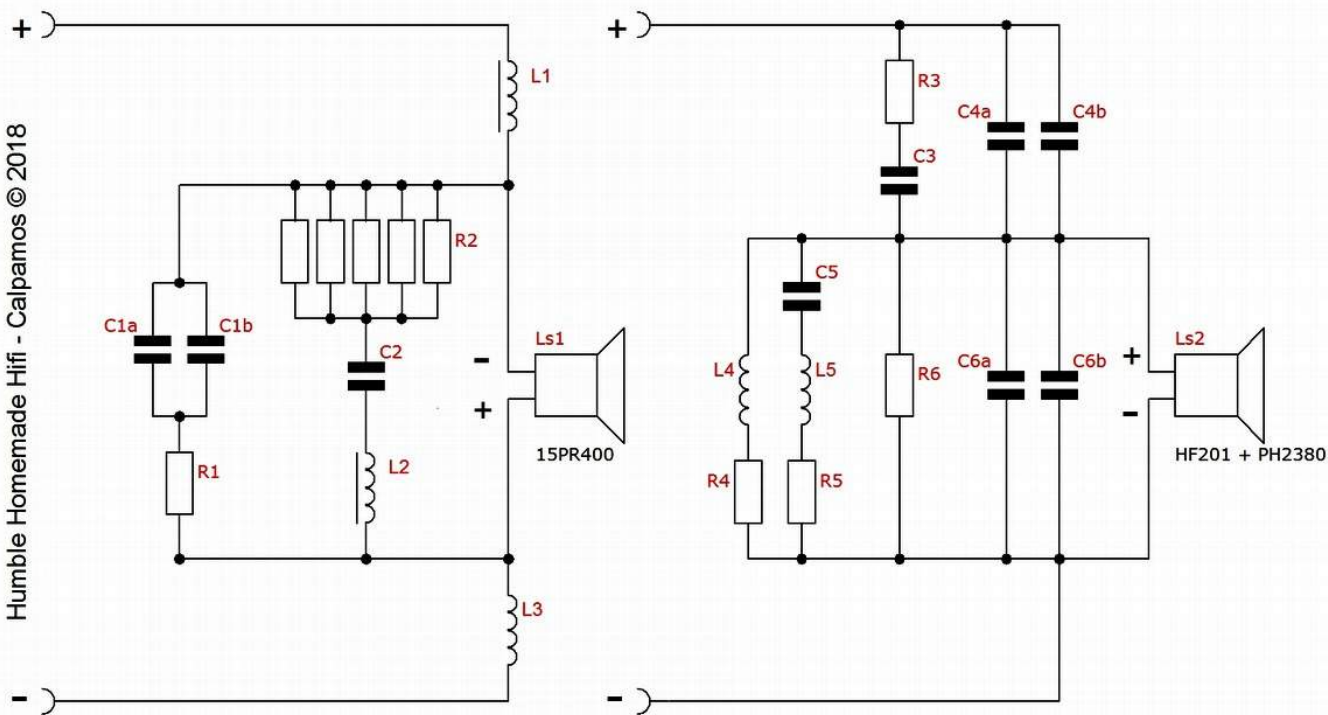
THE CROSSOVER

Designing the crossovers for the Calpamos turned out to be quite a tricky job. Pro drivers like these work like an acoustic "magnifying glass", even the smallest alteration to a component value or even component type made a big difference to the sound. That is also one of the reasons why the component quality is very high. Using standard quality components was like driving around in your car with the hand-brake on. This effect was even noticable with the impedance correction network in the low bass. In this LCR-network I had to use a very large metallized polypropylene foil capacitor of several hundreds of microfarads instead of the usual small bipolar electrolytic capacitors. The MKP gave more detail and improved dynamics in the upper bass region. Another example: for optimum system coherency I ended up using a Jantzen Audio Silver Z-Cap parallel to the midwoofer and Jantzen Audio Superior Z-Caps parallel to the tweeter. When all capacitors were Silver Z-Caps the treble became a little too forward (still using the same values) and when all capacitors were Superior Z-Caps the lower midrange lacked a bit of punch or drive. High quality crossover components are physically much larger and heavier than standard quality types so the end product consists of two crossoverboards per loudspeaker, each 165 x 240mm in size. The shipping weight for just a pair of crossovers is 15kg's!



The two-way crossover for the Calpamos is a modified second order parallel network. The low-pass section for the midwoofer is formed by inductors L1 + L3 and capacitor C1. Resistor R1 damps capacitor C1 slightly to create optimum phase integration around the crossover point. To maintain maximum efficiency the two inductors that are in series with the midwoofer had to have very low internal resistance R_{dc} . Therefore inductor L1 is a 10AWG Mundorf MCoil CFS10 Stack Core copper foil and L3 is a Jantzen Audio 8AWG Cross Coil copper foil inductor. Their combined value for R_{dc} is less than 0,15 ohms. The tweeter high-pass is formed by capacitor C3 (a Jantzen Audio Alumen Z-Cap) and inductor L4 (a Jantzen Audio Litz Wire Wax Coil). Here also, a resistor is added in series with the parallel leg to create better integration around the crossover point. The tweeter output level is lowered to match that of the midwoofer by means of an L-pad formed by resistors R3 and R6. These two resistors also have the function of smoothing the overall impedance of the tweeter so that the high-pass crossover "sees" a constant load. All resistors are Mundorf MResist Supreme except for the resistors in the midwoofer's impedance correction network.

For the low-pass network to work correctly an LCR impedance correction network is placed parallel to the midwoofer. This network ($L2+C2+R2$) smooths out the second impedance peak of the port tuning frequency to create a constant load. Five resistors are connected in parallel to obtain the desired value and increase power handling. Parallel to the tweeter there is also an LCR-network ($L5+C5+R5$). This network doesn't correct any impedance peaks but is designed to tailor the frequency response curve in the lower treble region. The remaining capacitors C4 and C6 determine the tweeter's signature in the critical top octave. The larger capacitor C4a is an Intertechnik Audyn True Copper Max copper foil capacitor. It bypasses R3 and C3 to give very natural sounding harmonic overtones. Capacitor C6 has a low-pass function that lowers a peak just under 20kHz. Without this capacitor the titanium compression driver can sound a little on the bright side of neutral. Adding C6 made the overall sound much smoother, I would even go as far to say that with C6 in place the treble has a warmish tone to it. The final icing on the cake is done by several Cornell Dubilier bypass capacitors, a 942C in the woofer section and a couple of 3000VDC 940C's in the tweeter section.



Inductors

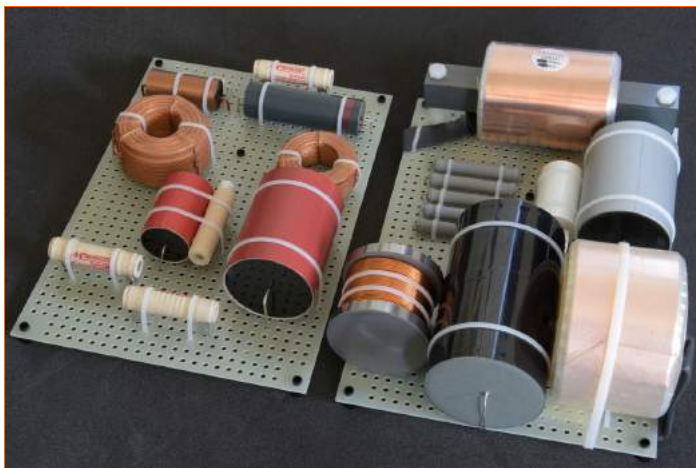
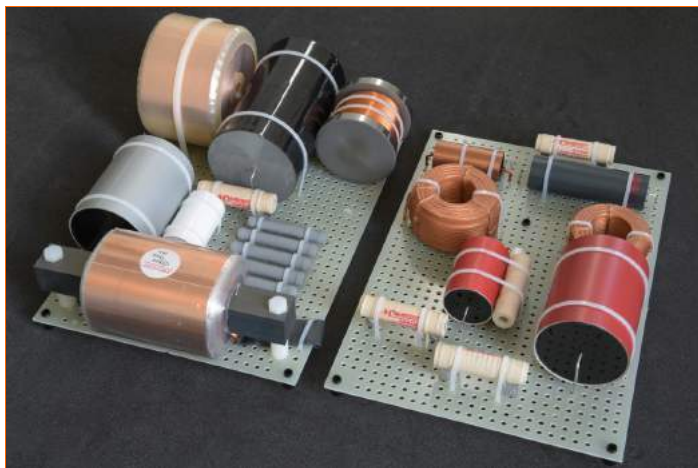
- L1 = Mundorf MCoil 10AWG CFS10 Stack Core copper foil
- L2 = Jantzen Audio 18AWG Iron core with discs
- L3 = Jantzen Audio 8AWG Cross Coil copper foil
- L4 = Jantzen Audio 15AWG Air Coil Wax Litz Wire
- L5 = Jantzen Audio 15AWG Air Coil Wax Litz Wire

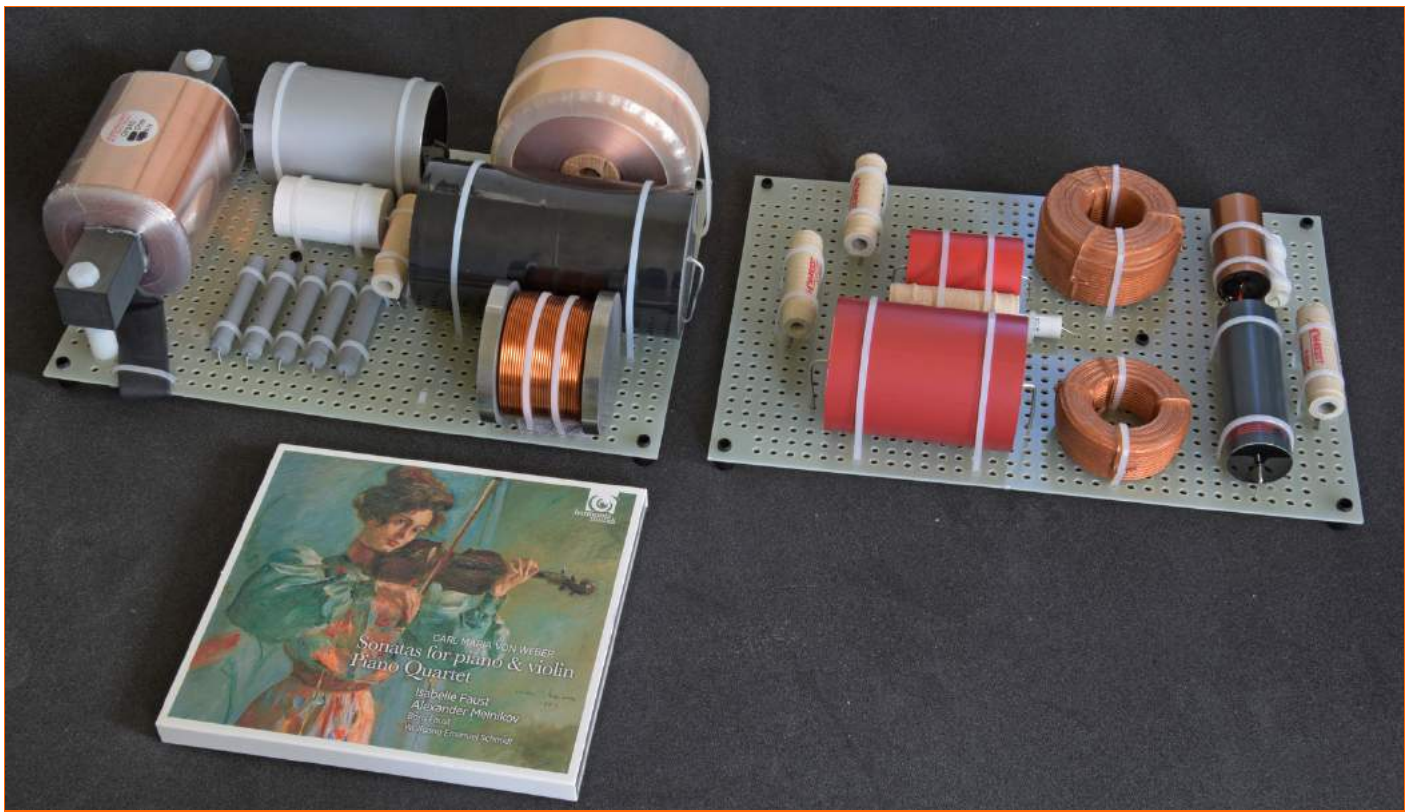
Resistors

- R1 = Mundorf MResist Supreme / 20 watts
- R2 = Jantzen Audio MOX / 5x 10 watts
- R3 = Mundorf MResist Supreme / 20 watts
- R4 = Mundorf MResist Supreme / 20 watts
- R5 = Mundorf MResist Supreme / 20 watts
- R6 = Mundorf MResist Supreme / 20 watts

Capacitors

- C1a = Jantzen Audio Silver Z-Cap / 800VDC
- C1b = Cornell Dubilier 942C / 2000VDC
- C2 = Jantzen Audio Cross Cap / 400VDC
- C3 = Jantzen Audio Alumen Z-Cap / 100VDC
- C4a = Intertechnik Audyn True Copper Max / 630VDC
- C4b = Cornell Dubilier 940C / 3000VDC
- C5 = Jantzen Audio Superior Z-Cap / 800VDC
- C6a = Jantzen Audio Superior Z-Cap / 800VDC
- C6b = Cornell Dubilier 940C / 3000VDC



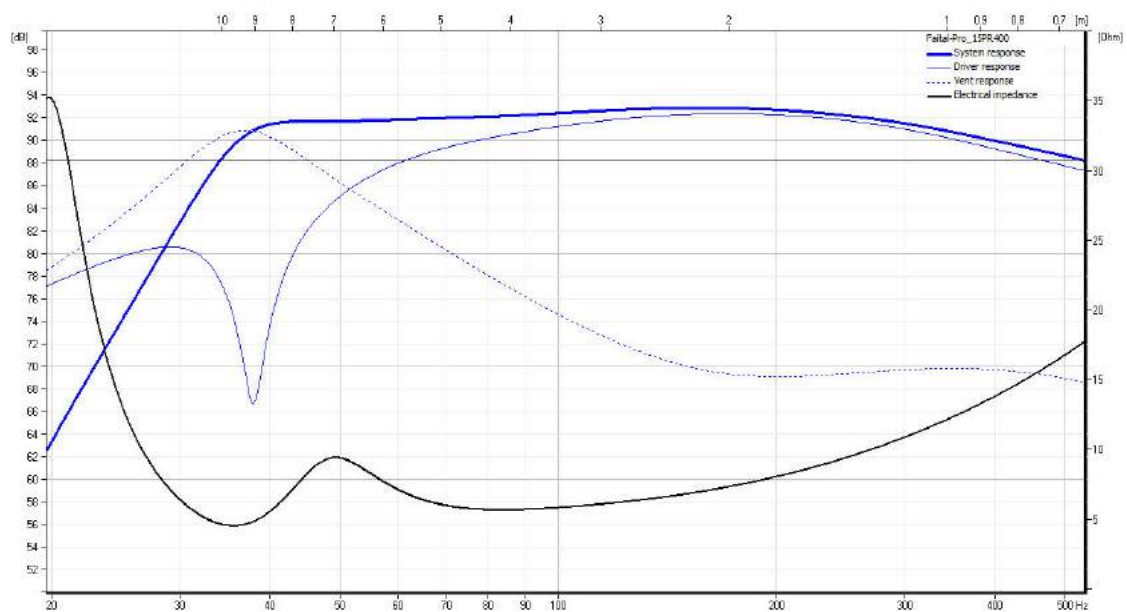


The separate crossovers for the woofer and the tweeter are placed at the bottom of the enclosure, towards the rear. Make sure that they are positioned in such a way that the inductors of one crossover-board are not too close to the inductors of the other board. The crossovers are held in place with woodscrews that are screwed into the solid wood timber frame.

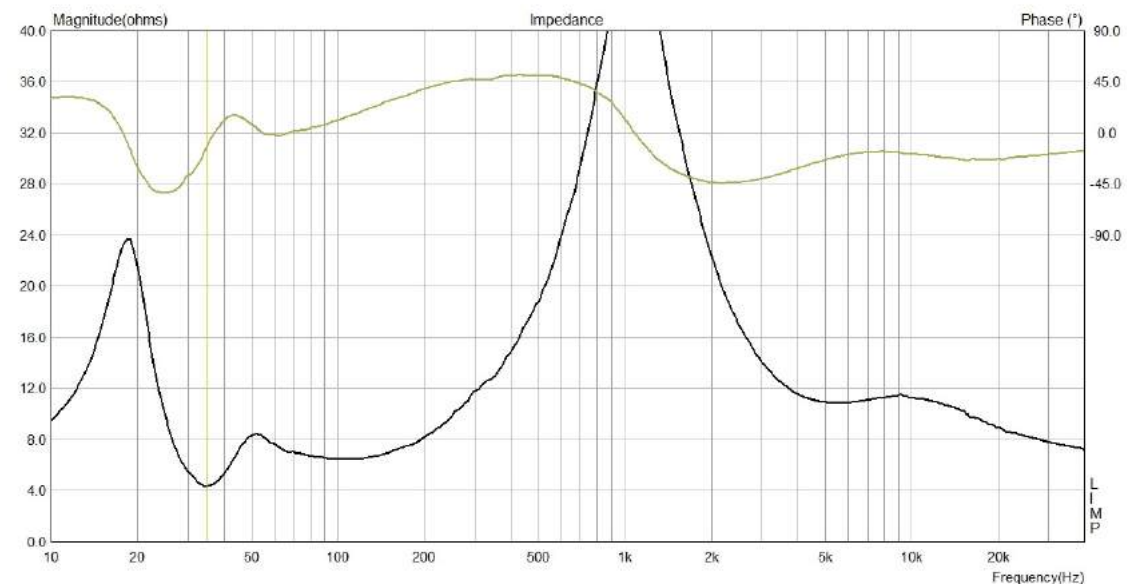


MEASUREMENTS

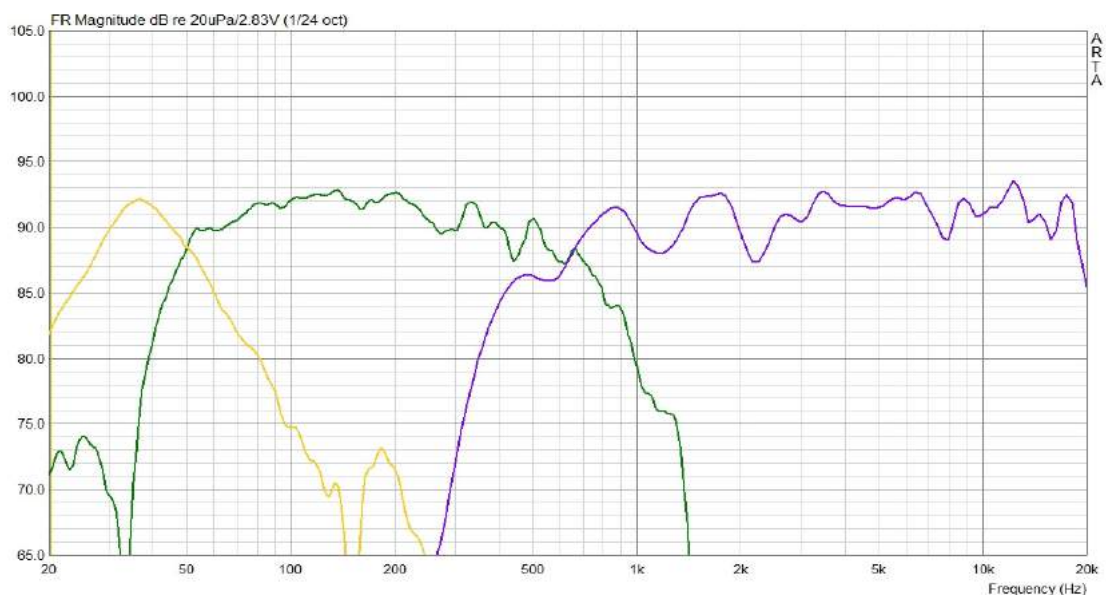
Getting reliable and consistent measurements from large midwoofers and horns such as these turned out to be quite tricky. Seeing that the standard measuring distance for loudspeakers is 1 meter and basically the radiating surfaces of the Calpamos are rather large in comparison to this measuring distance, I had to take more measurements than usual and at various distances to be able to obtain measurements that say anything meaningful about how this loudspeaker performs.



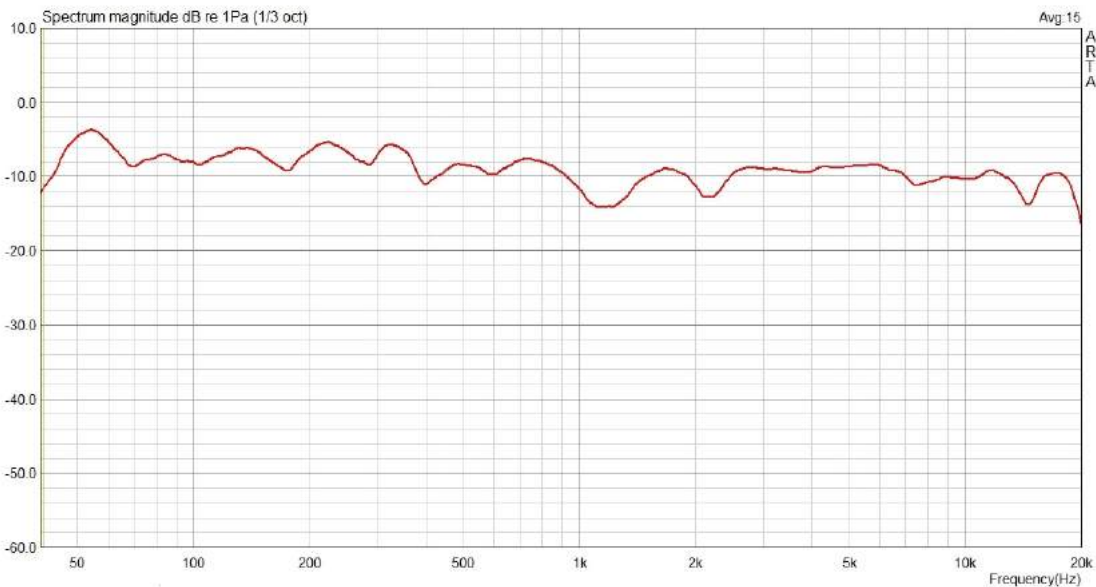
Modelled vented box woofer frequency response (thin blue line) / port frequency response (dotted blue line) / summed frequency response (thick blue line) and corresponding impedance response with crossover (black). Range 20Hz - 500Hz; Vertical SPL scale 50dB to 100dB's; Vertical impedance scale 0 ohms to 40 ohms's.



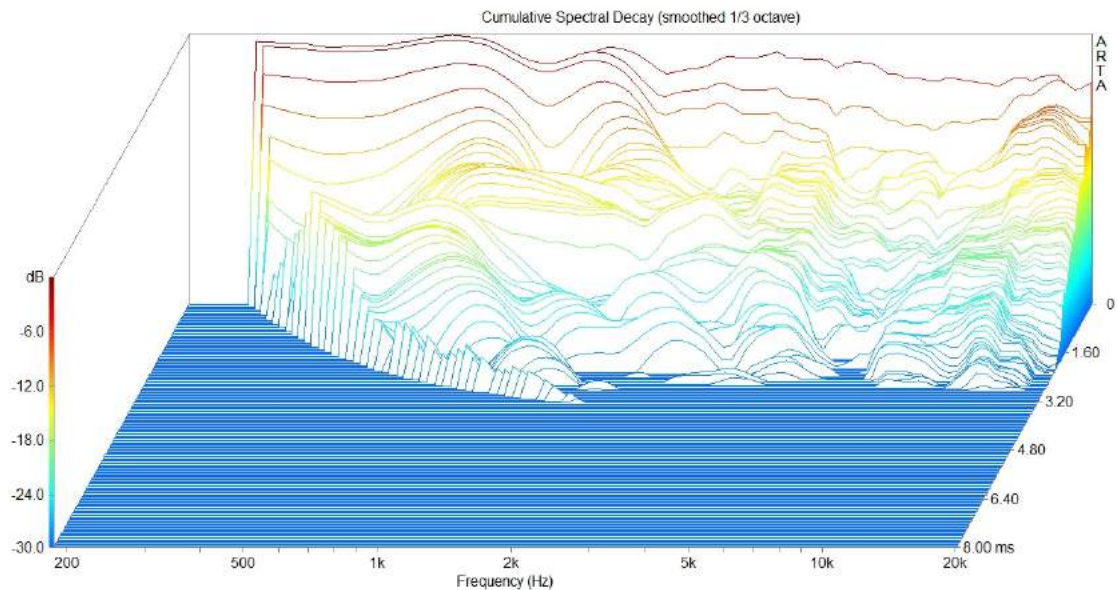
Measured impedance plot of the Calpamos. It's nominal 8 ohm impedance shows an easy load for most amplifiers. The impedance minimum corresponds with the port tuning frequency and is 4,4 ohms at 35Hz. Frequency range 10Hz to 40kHz; Vertical scale zero to 40 ohms with sub divisions of 4 ohms.



The individual frequency measurements of the drivers and the port. The yellow curve is the combined output from the two bass reflex ports, the green curve shows the output of the Faital Pro 15PR400 midwoofer with crossover and the purple curve shows the output of the Faital Pro HF201 compression driver + P-Audio PH2380 horn with crossover. The maximum output of the ports can be seen at just above 35Hz and the acoustic crossover point between the two drivers is situated around 650Hz. Frequency range 20Hz to 20kHz; Vertical scale 65dB to 105dB's with sub divisions of 1dB.



The frequency response taken from 15 averages measured in the listening-room at 3 meters distance. This corresponds quite well with the perceived response as heard when listening to these loudspeakers. Overall well balanced. To level out reflections caused by any objects, etc in the listening room, 3rd-octave smoothing has been applied. All the other measurements have normal standard 24th-octave smoothing. Frequency range 40Hz to 20kHz; Vertical scale +10dB to -60dB's with sub divisions of 2dB's.



The cumulative spectral decay of the finished system shows a reasonably smooth decay. Range 200Hz - 20kHz; Vertical scale 0dB to -30dB's; Time scale 8 milliseconds.



LISTENING IMPRESSIONS

The Calpamos produces music with the utmost ease. The extremely neutral presentation is combined with an impressive dynamic range with heaps of detail and at the same time very smooth. The horn tweeter works like an acoustic magnifying glass letting you hear very deep into the recording, retrieving information that otherwise gets lost with "normal" hifi speakers. The horn treble has absolutely no "horn signature" at all other than great dynamics. It is smooth, actually even slightly on the warm side of neutral. Bass is extremely tight, never bloated nor slow, and is deep and powerful. The Calpamos will do deep bass that you can feel. A good example is the track *"Rull"* on the recording *"What was said"* by Tord Gustavsen, Simin Tander and Jarle Vespestad. This track starts with a drum intro that sounds very impressive and is lots of fun to listen to! Overall the sound of the Calpamos is very coherent, there is no audible crossover point, the two drivers blend together seamlessly. Here is a [video](#) of the Calpamos to give you a quick impression.



"Amazing sound! Oh man they deliver! The whole house is shaking. The dynamics are scary, whatever I feed them from Classical to Hard Rock they sound impressive. Before I didn't like to listen to Hard Rock or Classical Music, there was too much clatter and noise I didn't enjoy. But with these speakers I've never heard AC-DC sounding like that in my life, so clean even at loud levels. The bass is not boomy but is so strong I feel it in my chest. Now I have only one problem, I can listen only when wife is not at home, LOL."
(Marius - Thornhill, Canada)





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