updated April 29th, 2024

ELTIM speaker design philosophy

While using multiple units in a loudspeaker system, every specific unit receives a specific frequency range where it is specialised in. If the design is built correctly, the image of the total is a simulated presentation as if it is all one. As we all are aware of, in many systems this is NOT the case.
Non-technicians mostly see a loudspeaker system as one part, which is logical, you also see your car as ONE part…. Technicians as we are, see them in parts though and tend to see flaws all over.
We believe the use of high order parallel crossovers is wrong and felt the need to change.

A loudspeaker system is the result of technical efforts to match three acoustic/electric parameters, preferably resulting in a:

- Flat frequency curve *("feels" logical and therefor tried to match by most)*
- Flat impedance curve *(any amplifier will "like" that and not presenting difficulties in sound)*
- Flat phase curve *(where our ears/brain are most sensitive for, resulting in easy listening)*

In practise we are overruled by nature's laws unfortunately and must give in somewhere……
Sometimes it's the quality, sometimes the size, sometimes the price, yet mostly imperfect curves.
Most designers go for a perfect frequency graph, ignoring the huge phase- and impedance changes caused around the crossover frequencies.

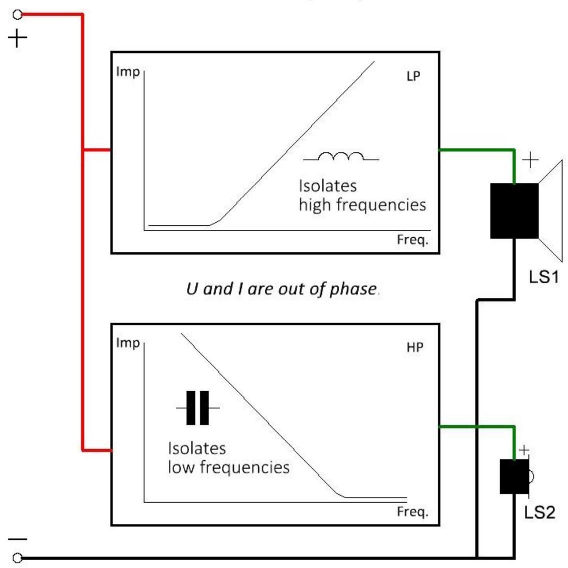
Over the years about everybody, especially the DIY community, believes that a speaker with the flattest (and widest) frequency range results in the best performance. I'm sorry but you're wrong in that. Phase behaviour is, since our ears are very sensitive in detecting phase shifts and way less in frequency errors. Also, because frequency behaviour is dramatically influenced by the room the speakers are in and the location in this room as well, in our opinion matching the frequency domain is of second importance.
If the phase behaviour is out of order though, the 3D presentation is always down the drain !
At first a dramatic phase behaviour sounds fantastic (as the largest brand is specialised in….), but after some time one gets fatigued and worse, stops listening. We believe we managed to solve this problem.
To tell how, we need to go in some technical details.

Parallel filtering.
In most speaker systems, every drive unit receives its specific frequency range for optimal performance. This filtering can be done in many ways. The steepness of the filtering can be different (6, 12,18 or even 24dB/octave).
Also, there are several types of filters.
For those interested: we made an Excel table where you can view and alter all available parallel filtering types.
Every type and every slope will result in a different sound, while using the same drive units. This proves that something happens in these type of crossovers which is altering the sound, but WHAT and WHY???? Also proof that they are not working as one expects them to do. Many spent hours on that theme.

Immediately after the speaker terminals, the signal is split in 2 or more separate frequency ranges as shown at the right:

Clearly is shown that from that moment on, both frequency ranges don't "see" each other anymore.
The phase (= 3D presentation) is the result of the voltages and currents floating in a circuit.

Parallel XO principle



Note that the impedance of the crossover part is given, not the frequency curve!
The crossover parts isolate the driver from a frequency range.

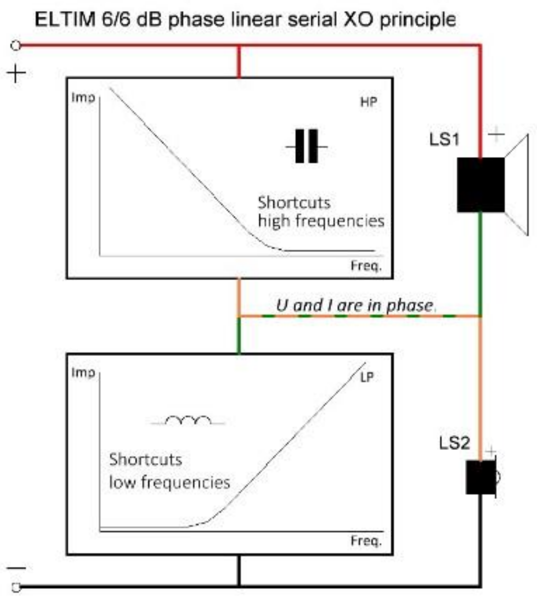
Since we completely separated the frequency ranges here, depending on the type of filter and drive unit used, each part will behave in its own way, regardless of what the other parts do. Voltages and currents (= phase response) are not matched. Every filter part has a very low impedance (=ac resistance) in its working range. Around the crossover frequency, the impedance is rising at a certain rate, f.e. 12dB/octave. So, from a certain frequency point on the specific unit won't get signals anymore. Unfortunately, this rise in impedance results in a dramatic phase shift also, simply law of nature. The higher the crossover slope, the more dramatic the phase response changes around this crossover frequency.
Designers tend to match the total frequency range, by shifting the two "Lego" blocks over the frequency axis. Sometimes this results in a huge impedance rise and phase (= 3D presentation) shift around the crossover point. But: frequency is matched.

In practise, this kind of filtering shows about perfect frequency behaviour, but the phase and impedance curves show dramatic results, especially in the crossing area. This is one of the reasons why speakers sound so different.
BUT: as most people want it: the frequency curve is about flat. Then, placed in a living room, this room is heavily degrading this "flat" frequency curve, but sois. Also, while repositioning the speaker it changes, as you all are aware of.
The phase curve however, defining the spatiality of the presentation, stays intact regardless the characteristics of a listening room. Besides that, and more important: our ears and mind are concentrating on and are specialised in phase differences, just to find out where the "danger" is coming from! The phase shift between both ears defines the location. And even more precise: the phase shifts of reflected sounds give us an idea about the distance and even the vertical position of where the sound is coming from. How can you hear that a plane is right above you when your ears are listening forward?? Phase shifts of ground reflections! Only experienced people manage to hear 2-3dB (doubling of sound level!) differences. You like the sound of your smartphone? More than 10dB difference in the frequency domain !
So, we tried to find a solution where we could concentrate on the phase behaviour instead, resulting in an easier to place speaker, sounding as if it has only one unit. At the same time and "free" is an about flat impedance curve.

Serial filtering.

The serial filtering technique is known for many years, but hardly implemented in the audio world. This is not because it can't work, but because designers use(d) drive units which can't cope the extra power they have to withstand outside their actual working area. Despite the few parts required it is very difficult to find the correct components values and the units which are able to handle the extra energy they receive outside their working area without breaking or distorting. About 95% of all units (especially tweeters) are incapable of handling serial filter signals, to be more precise: 6dB filtering slopes as we use.

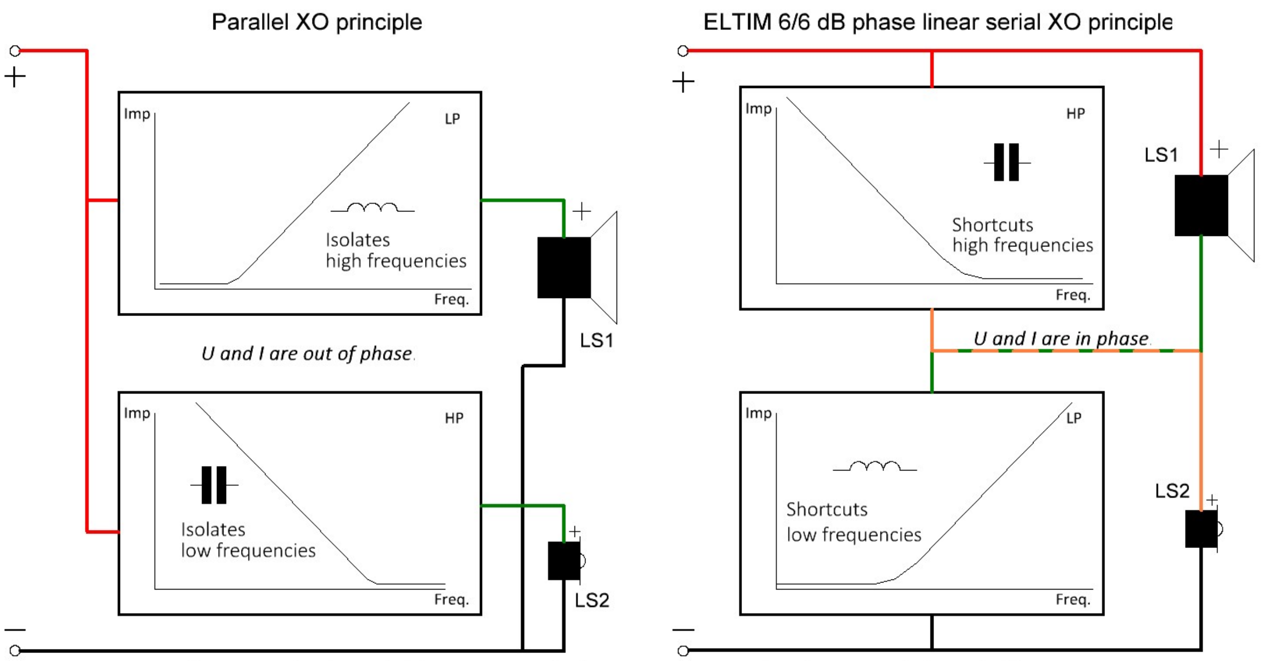
Since about everybody is used to "read" parallel filters, it's a bit tricky to read the picture at right, but we'll try to explain what happens. Both (or more) units are connected in series with each other, so without any precautions they would receive the same signal…..
We solve this unworkable situation with some electronic components.
Parallel over the woofer we place a 6dB high-pass filter (=capacitor), meaning that the impedance of this circuit is very low at high frequencies. So, the woofer is shortcut by this circuit at high frequencies. Over the tweeter the opposite happens; it is shortcut for low frequencies by the 6dB low-pass filter (=coil).
So, in parallel filters we isolate the drive units from unwanted , frequencies where in serial filters, we shortcut them instead.
The result is that on both upper and lower circuits, the voltages and currents are the same, basically resulting in a flat phase response. But we still need to do acoustic and electric fine tuning!



Note that the impedance of the crossover part is given, not the frequency curve!
The crossover parts SHORTCUT the driver from a frequency range.

About all attempts in designing a working serial crossover are done by numerous trial and error attempts, costing a lot of components and time. One of the reasons why it is hardly used.
In order to find the closest possible match, we made a program where we enter the drive units impedance, parameters AND acoustic performance. We can also "play" with components values and see in graph presentations what happens.
We do this till we find a frequency where the ACOUSTIC phase of both units are equal, at a point where the impedances of both units are crossing as well. This results in an about flat phase behaviour.

We succeeded to build several systems, working as about ONE speaker, even 3-way setups.
It is obvious that not any driver combination can be used in this serial crossover principle, not even from the same brand.

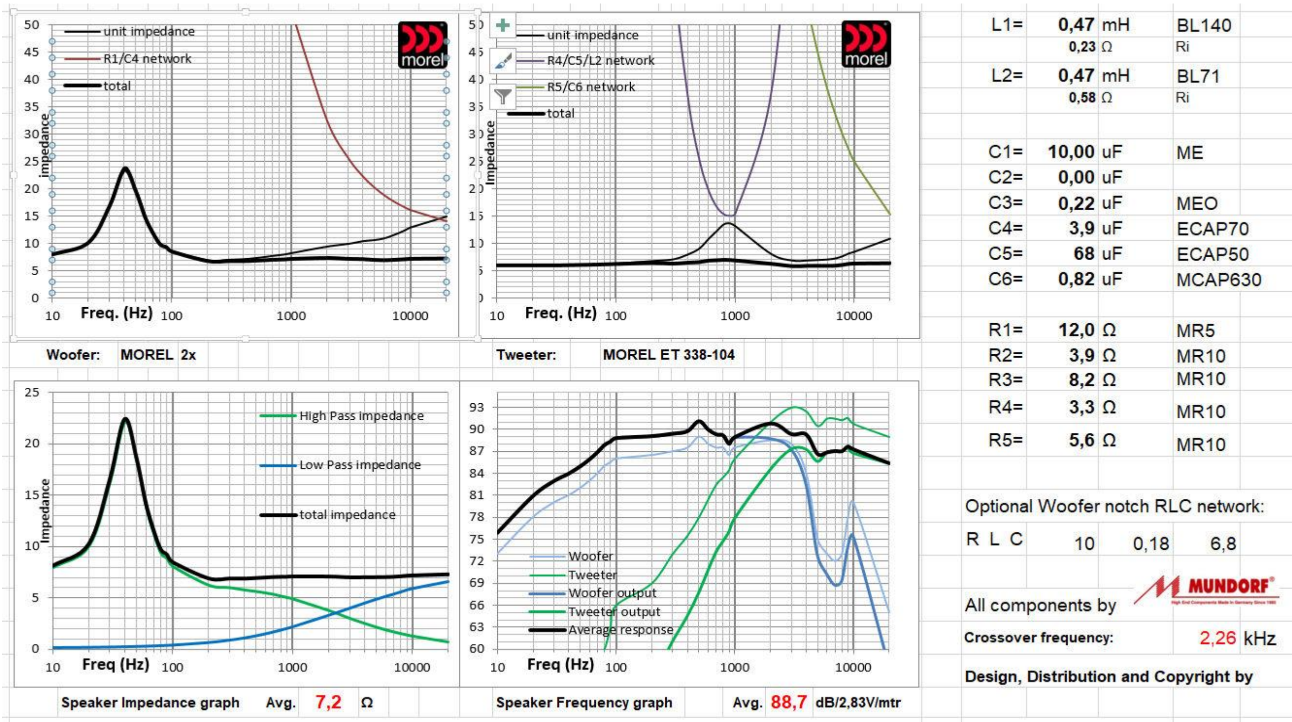


Unlike as in 12/12 (or 24/24)dB crossovers, the drivers are connected in phase in a 6/6 (or 18/18)dB crossover.

Our own software for calculating 6/6dB serial crossovers

Normally about all serial crossover designs fail because of two reasons: the first is that drive units are used which can't handle the remaining energy received outside their working area; the other one is that every part change will affect the complete functioning of the crossover results. This takes way to much time in "trial and error"listening/measuring.

The software we use is "just" some excel sheets with several formula's and al frequency/impedance data of the drivers we use. We enter all partsIn a sum sheet which looks as follows:



Here a presentation of a design in development. Impedances are matched already, frequency is in progress.

A serial crossover only works properly while the load impedance is about flat. So, before doing anything else we calculate parts to flatten the impedances of the units used. The finished results are shown in the upper graphs.
At left bottom these curves are combined with the crossover parts behaviour and shown in one graph. It's nice to know that due to this, the impedance curve (speaker load) of the speaker combination also is about flat, so ANY amplifier will drive our speakers without a problem. Besides the (relatively low) woofer resonance peak, the total curve is about flat.

The right bottom graph shows the combined frequency behaviour of the units in combination with the 6/6dB serial crossover parts. This is most tricky to develop since all parts interact with each other. Therefor we also need to consider the Rdc values of the coils used. We can also enter these values in our program. In this graph all is not yet settled yet, still working on.

The program shows us the acoustic frequency results as well as the independent and total impedance curve.
After some trial and error where we needed to understand what's going on and how to interpret the correlation between all data, it works fine for several years now. Only with this software we are capable to construct a functional serial crossover within a reasonable time. And only this is why others don't use it. It simply takes way too much time to develop it in a proper manner. And some would need better (=more expensive) units.

Now we only have to take care of the acoustical phase difference of the drive units used and caused by their stiffness and weight of the moving parts. This phenomenon is also known in parallel filters and solved by shifting the tweeter a bit back. Sometimes the tweeter signal is delayed by a delay circuit, as some brands used in the past.

Since the serial filtering technique only allows slopes of 6 or 12dB (requiring extra components again), the drive units need to show nice, smooth frequency curves around the crossover frequency. Also, outside their actual working area, especially tweeters, must be capable of handling lower frequencies, without overload or distortion. Audio Technology, Dynaudio, Morel, etc. can do this. To us it seems clear that these are not the cheapest units available.

As a cook wouldn't do, we don't tell exactly how this software works, but it does as we experienced in practise.
In our calculation program we have a database of all drive units we use, presenting the acoustic AND electrical data over the full audible frequency range. The combined behaviour of the raw drivers AND the crossover parts are shown in graphs.
Then, manually we alter components values till we find the correct crossing point, which is where the ACOUSTIC 6/6dB crossover frequency point matches the impedance crossing point. Sometimes it's done easy, sometimes even not possible.
We can see quite quickly whether planned units will match or not.

The combination of cabinet design, drive units (mostly MOREL) used and our serial crossover results in a most convenient, fast, easy listening sound, full of rich detail, lacking small "lobes" and presenting a fantastic 3D presentation in a wide "hot spot".
Perhaps it are our own amplifiers or the drivers quality causing it, but somehow the speakers also go "deeper" as you would expect from a woofer with a specific diameter.

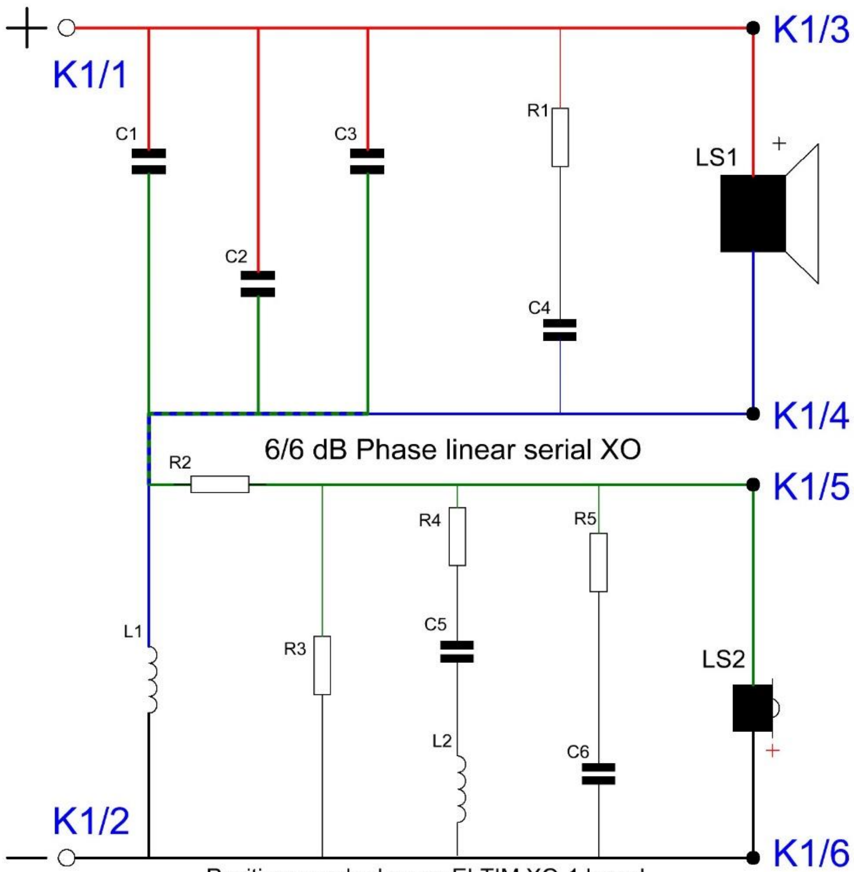
High-End dealers are most welcome -)

For the OEM market (only) we perhaps can process your drivers combination as well for a nice working speaker system.

Contact us

.

We developed a special PCB, suitable for all kinds of crossovers.
Basically, this [XO-1]() PCB is meant for use as our 6/6dB serial crossovers.
You can also use this PCB itself for LP, HP, BP and subwoofer filtering.



Positions marked as on ELTIM XO-1 board

This XO-1 PCB fits about all kinds of wire/foil coils, capacitors and resistors.