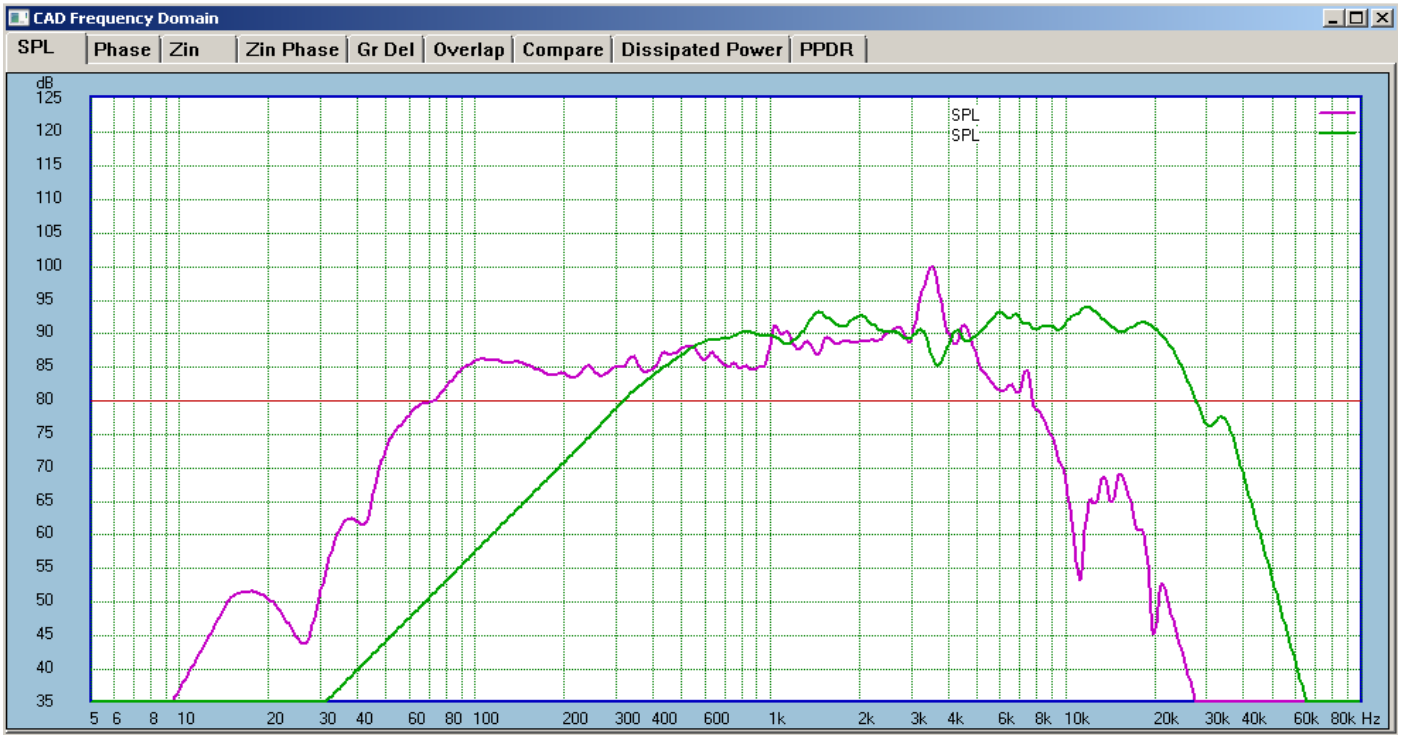
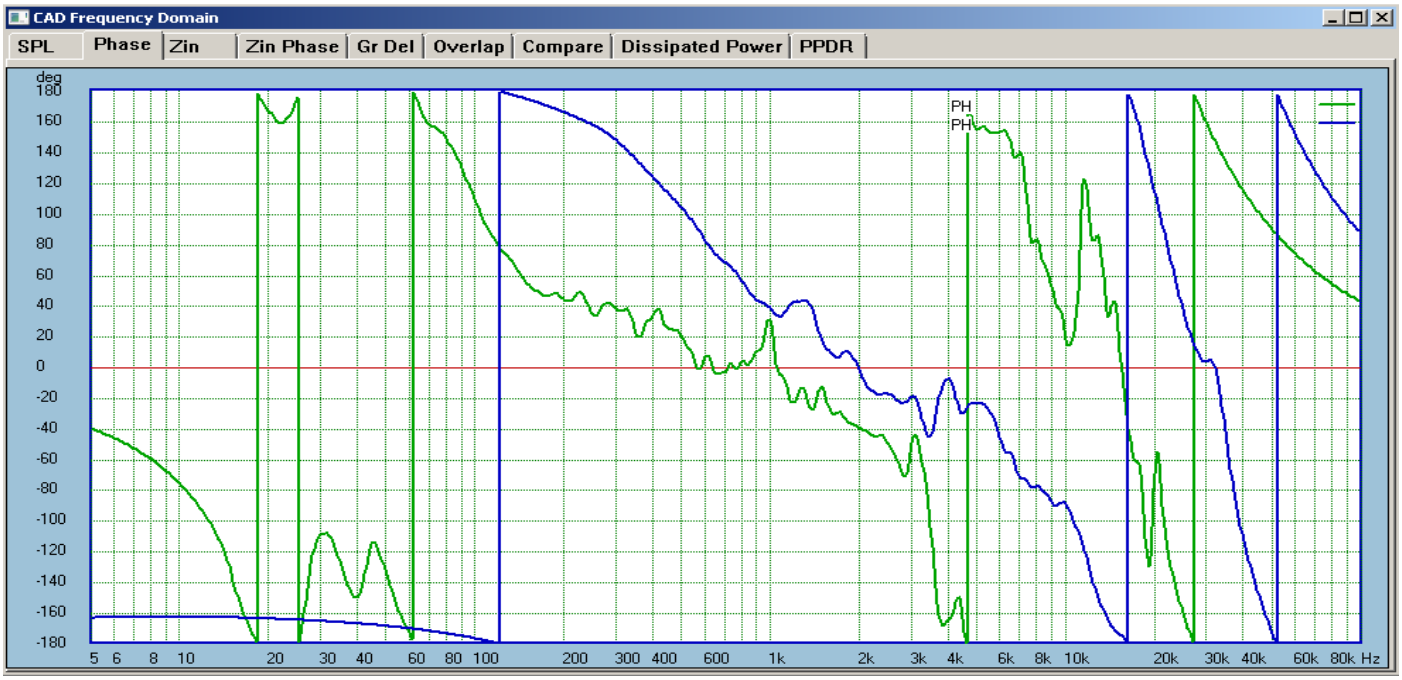
Using SE Optimizer For Quick Loudspeaker Design

This short paper, describes a couple if issues frequently encountered during loudspeaker design process. (1) An example design of a two-way loudspeaker system, with Linkwitz-Riley , 4th order crossover at 1.5kHz, and (2) amplitude peak equalization. The tool used for both processes is the Optimizer Function. Since the crossover is of the 4th order, the drivers are connected in-phase for normal operation. At this stage, we are not concerned about the availability of components with exact calculated values. Capacitors are easily paralleled, and coils can be easily modified to the required values.

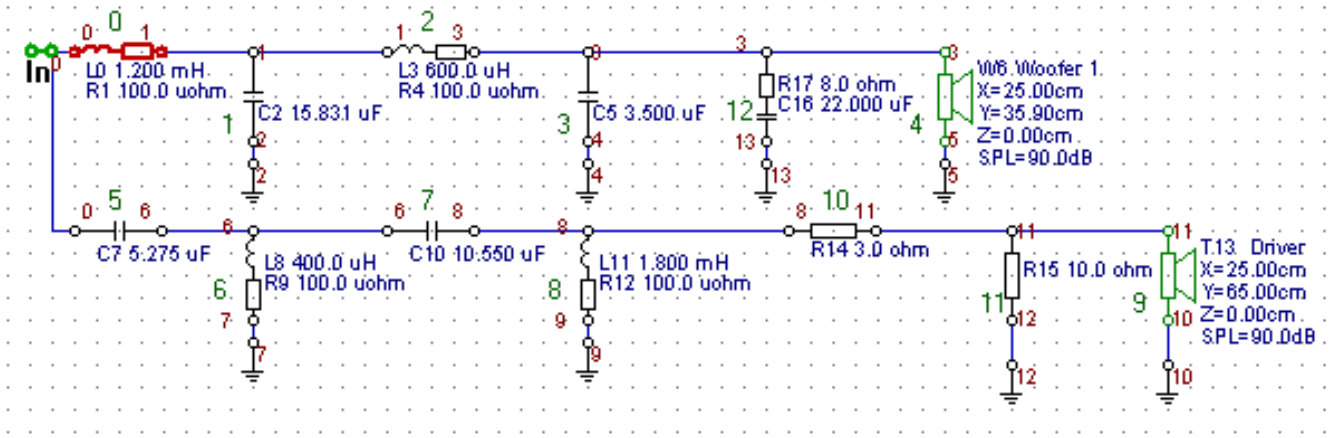
Our drivers are: Woofer (pink) and Tweeter (green) SPL curves. Drivers have been fully edited and are minimum-phase.



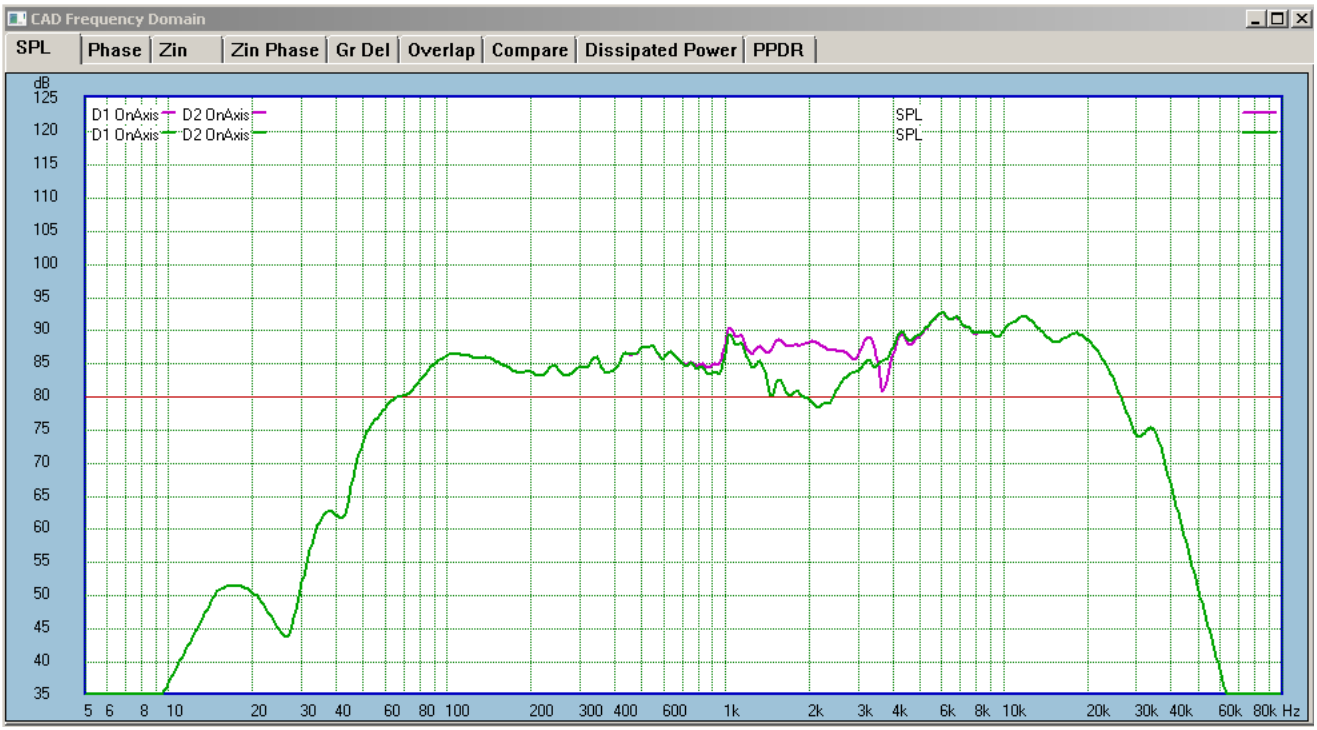
Woofer (green) and Tweeter (blue) Phase response curves



Crossover Original Values

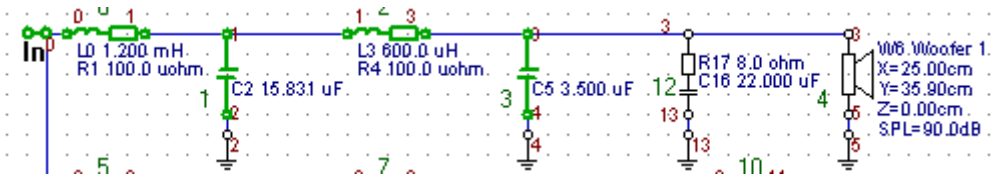


Original System Frequency Response (pink) and Reverse Null (green)

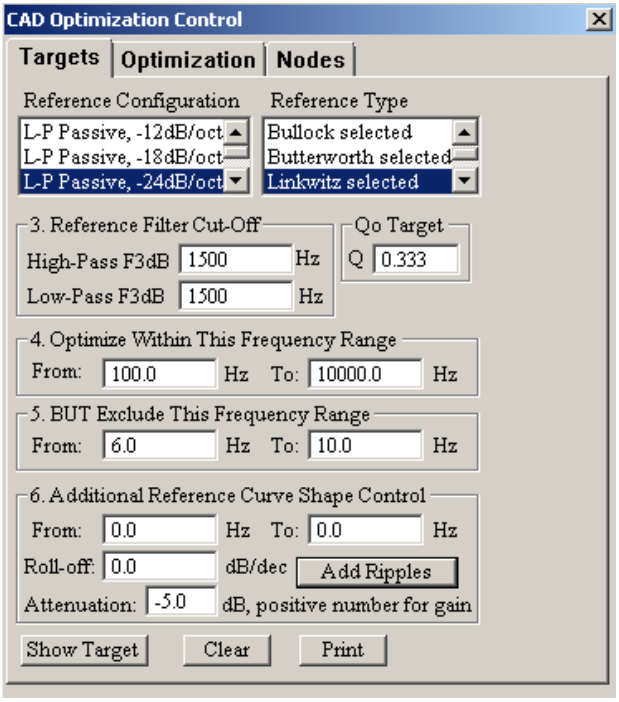


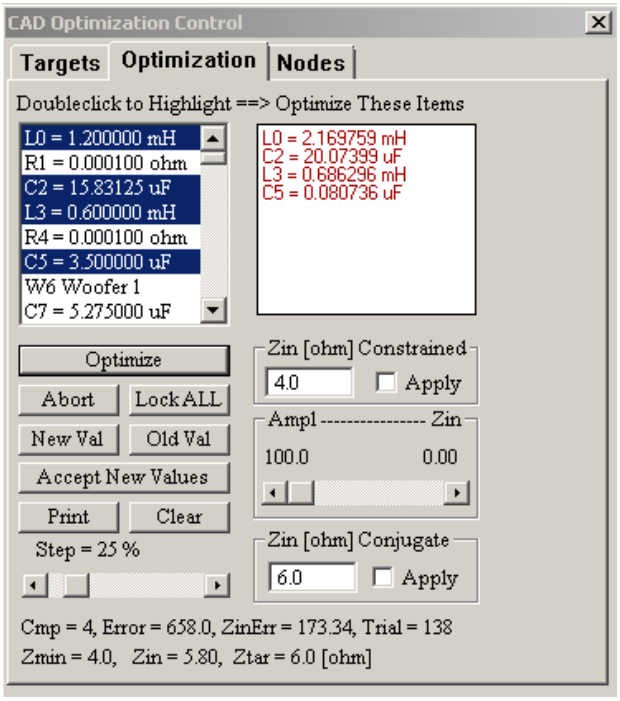
It is observable, that raw frequency response of the system is tilting upwards. This suggests, that tweeter efficiency is too high for the given woofer. Also, the "reverse null" is non-existent. This suggests, that phase responses at the crossover frequency are not 180deg and amplitudes are not -6dB both drivers. This loudspeaker would be lacking bass and sound overly bright.

Optimizing Acoustic Response of the Woofer

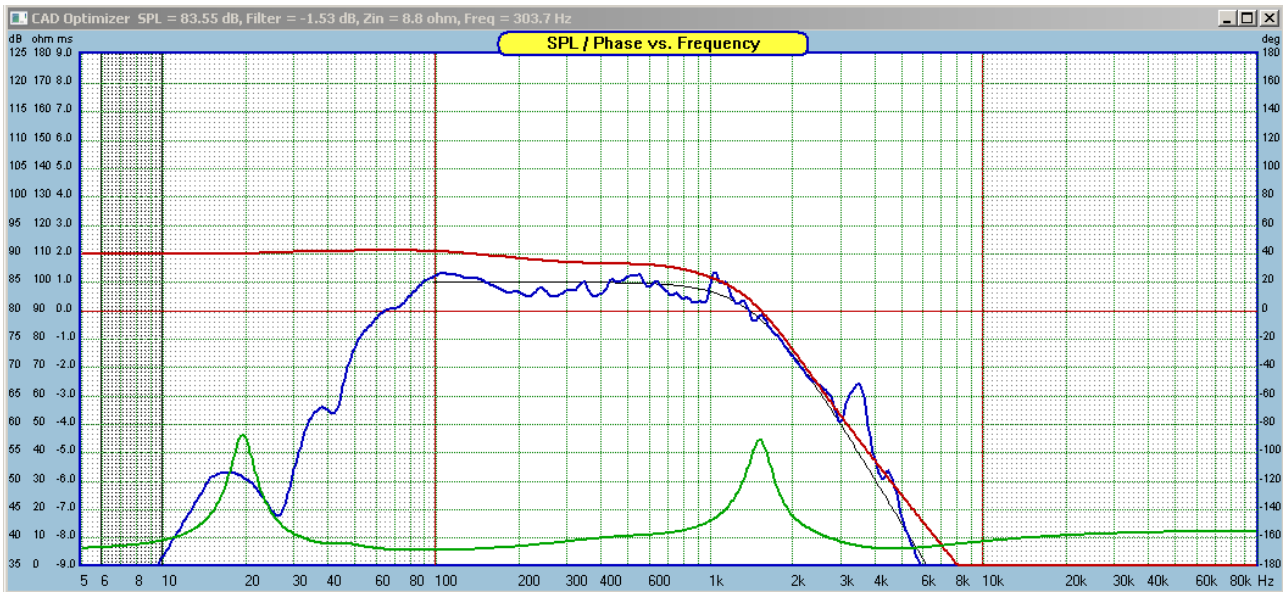


Optimization Parameters – 4 components: L0, C2, L3, C5. This is the whole low-pass section.

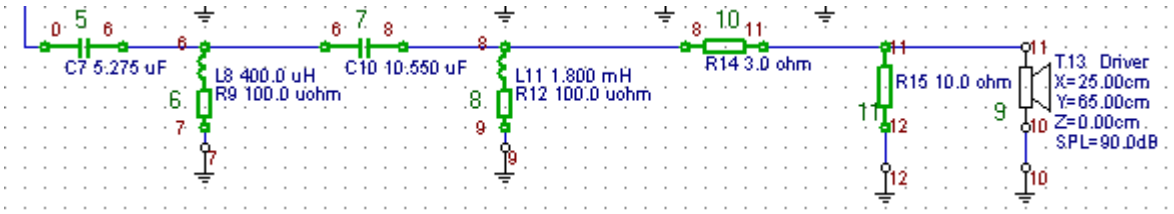




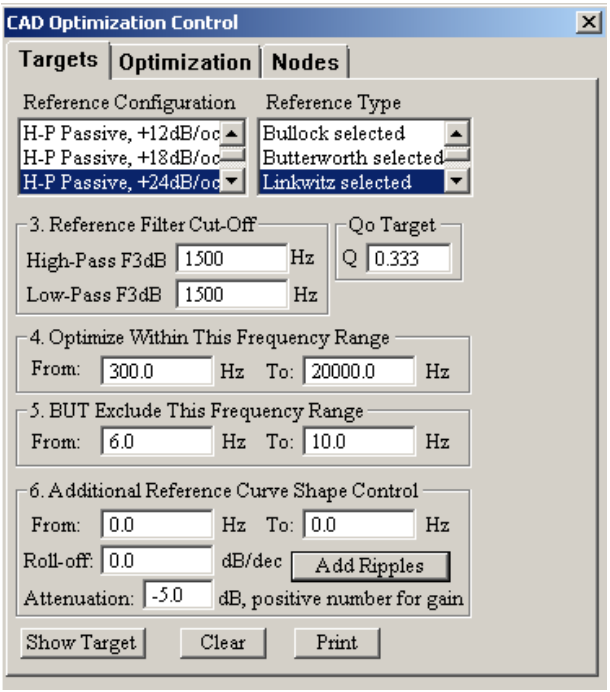
Optimized Woofer Filter SPL curve (brown).

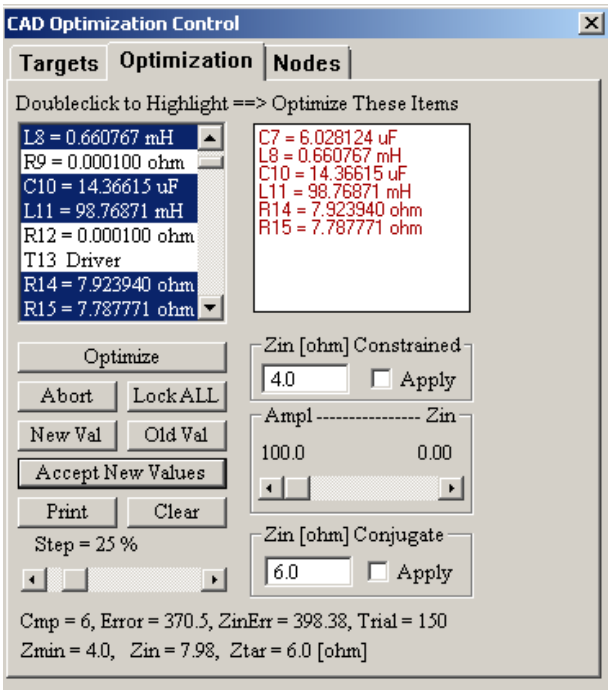


Optimizing Acoustic Response of the Tweeter

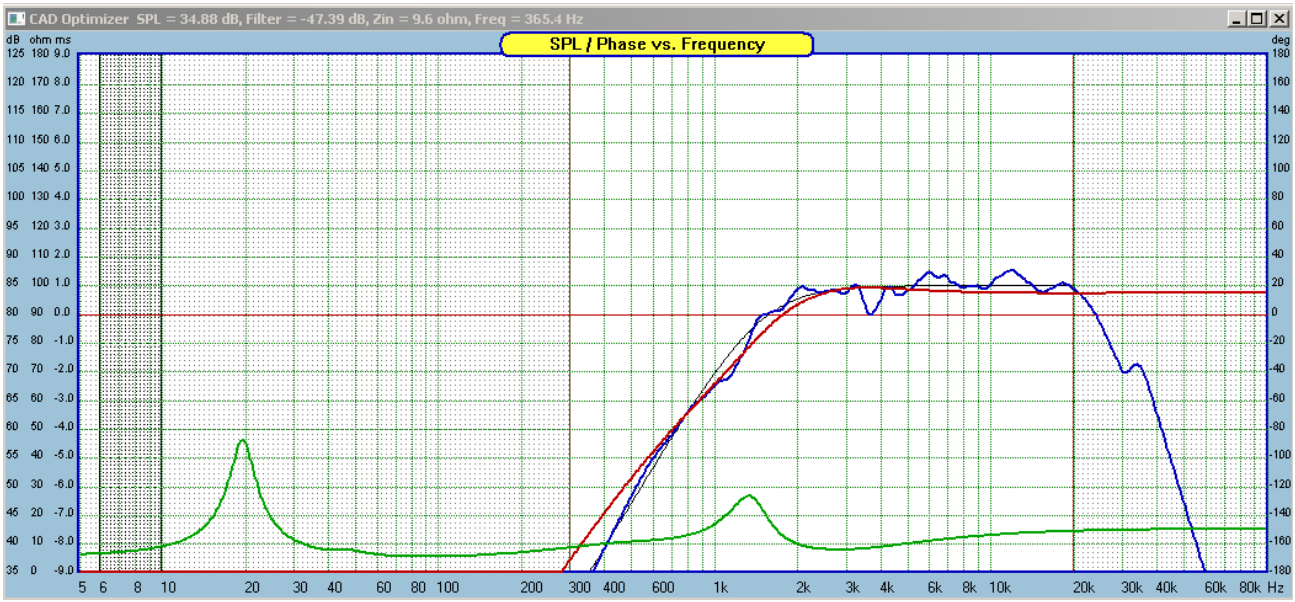


Optimization Parameters – 6 components: C7, L8, C10,L11 + L-Pad R14, R15

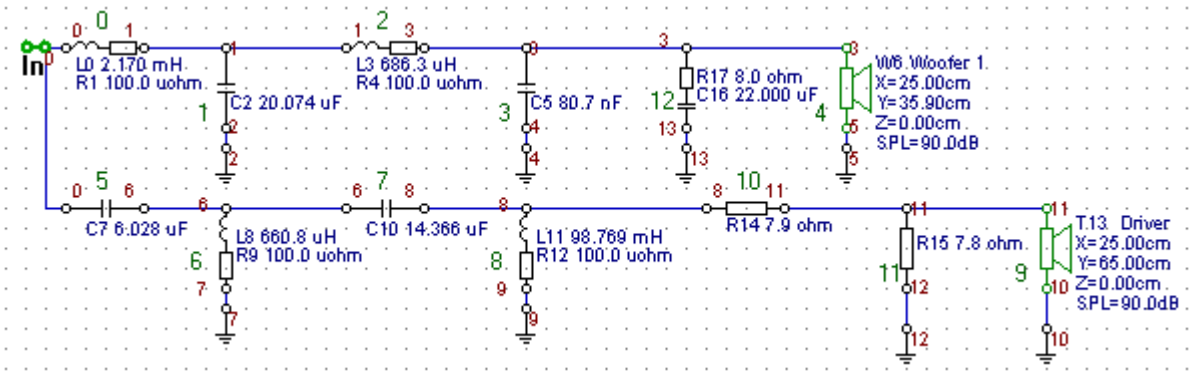




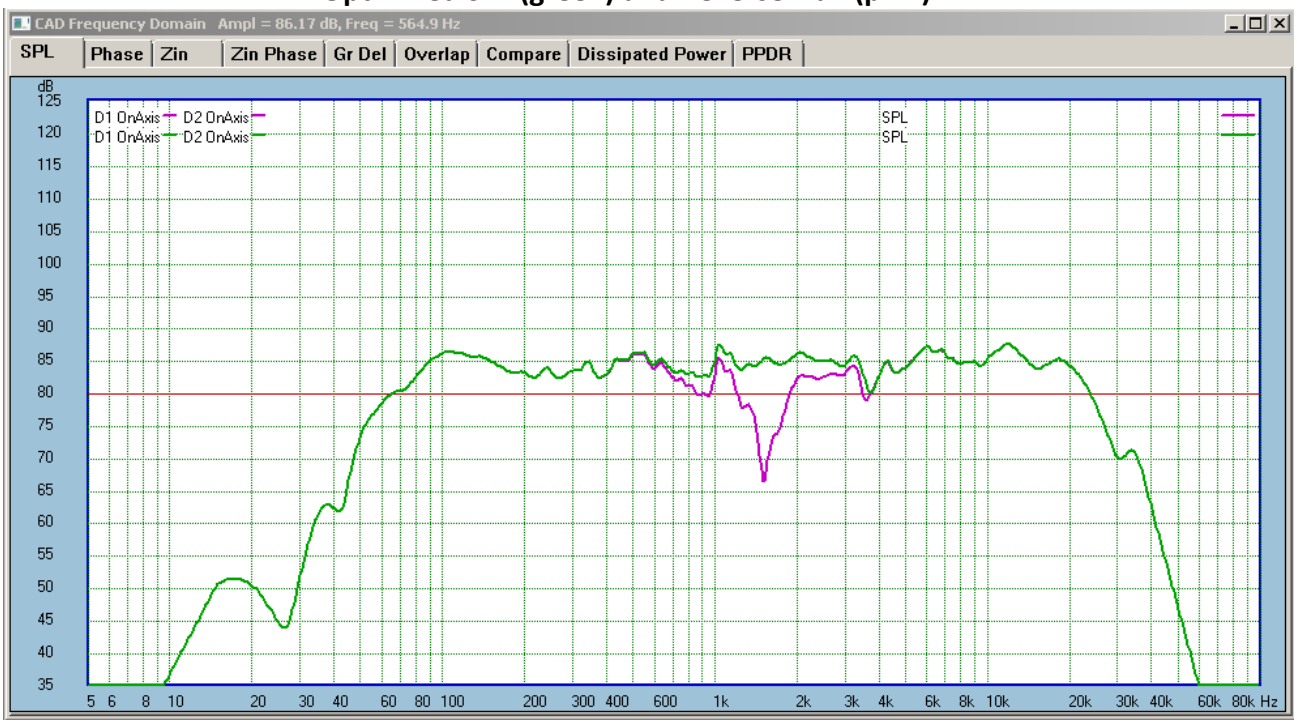
Optimized Tweeter Filter SPL curve (brown).



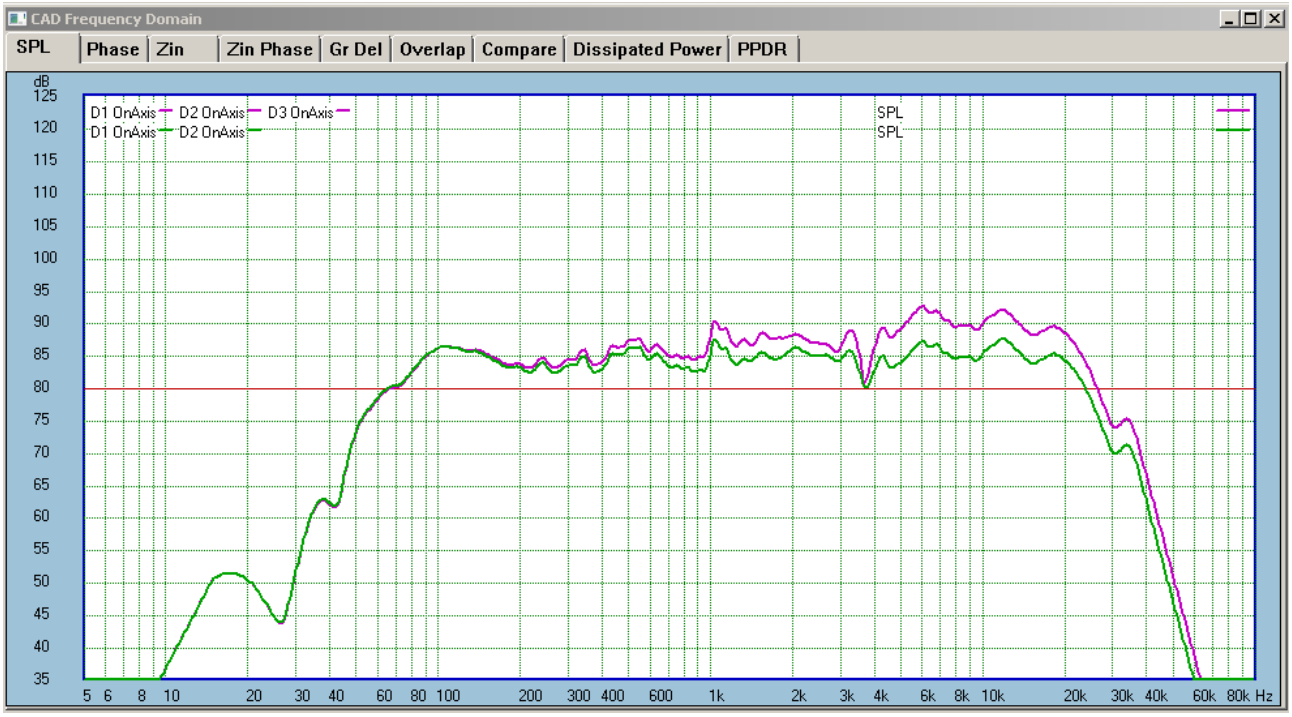
Complete Optimized Values



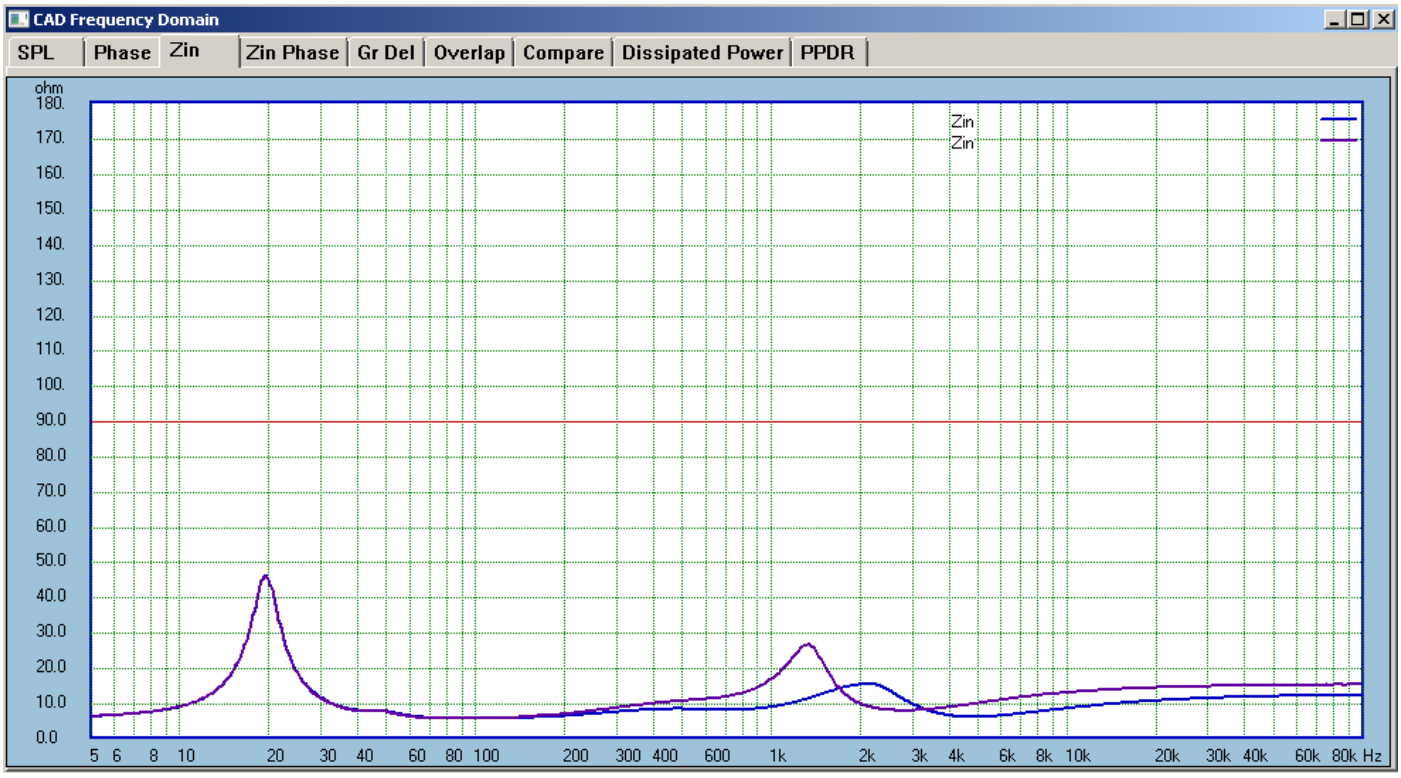
Optimized SPL (green) and Reverse Null (pink)



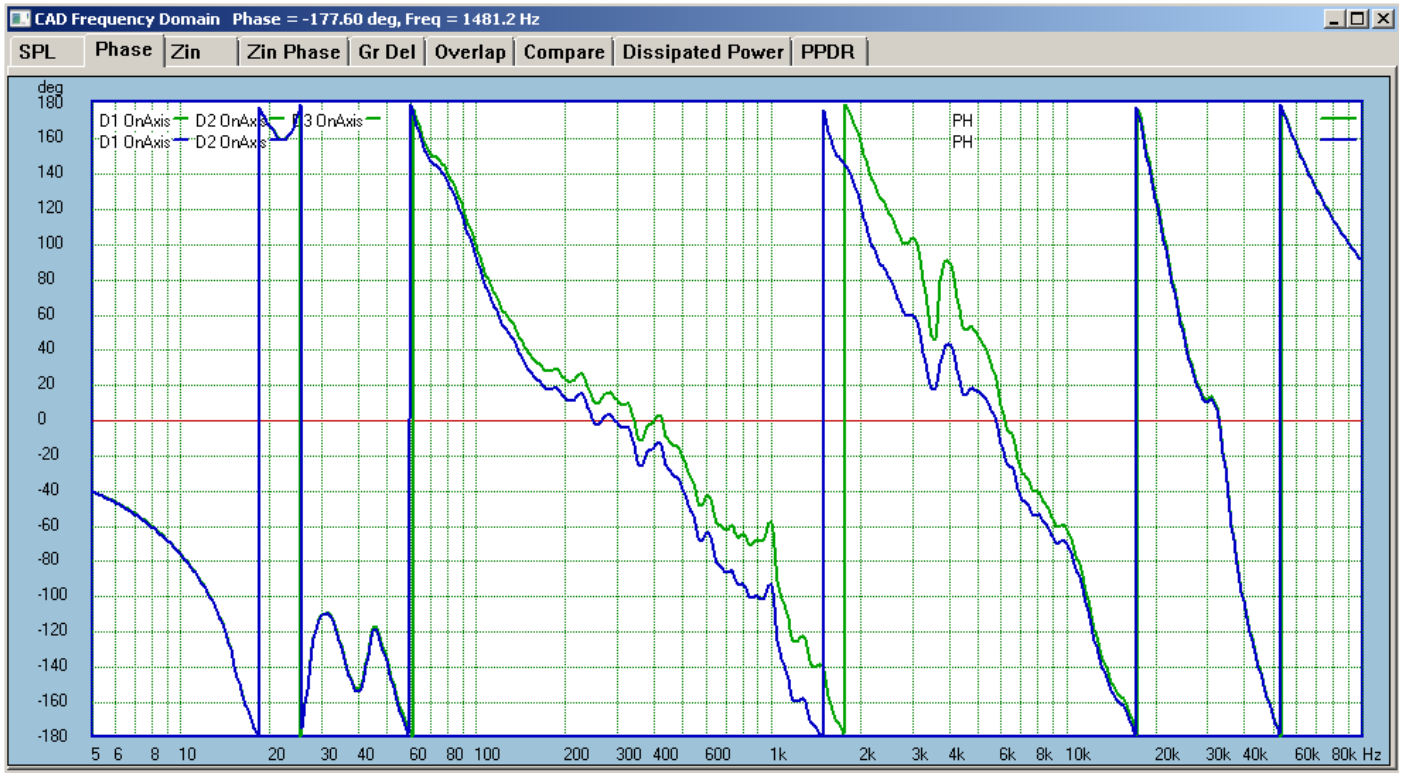
Before (pink) And After (Green) Comparison



Zin Before (violet) and After (blue)

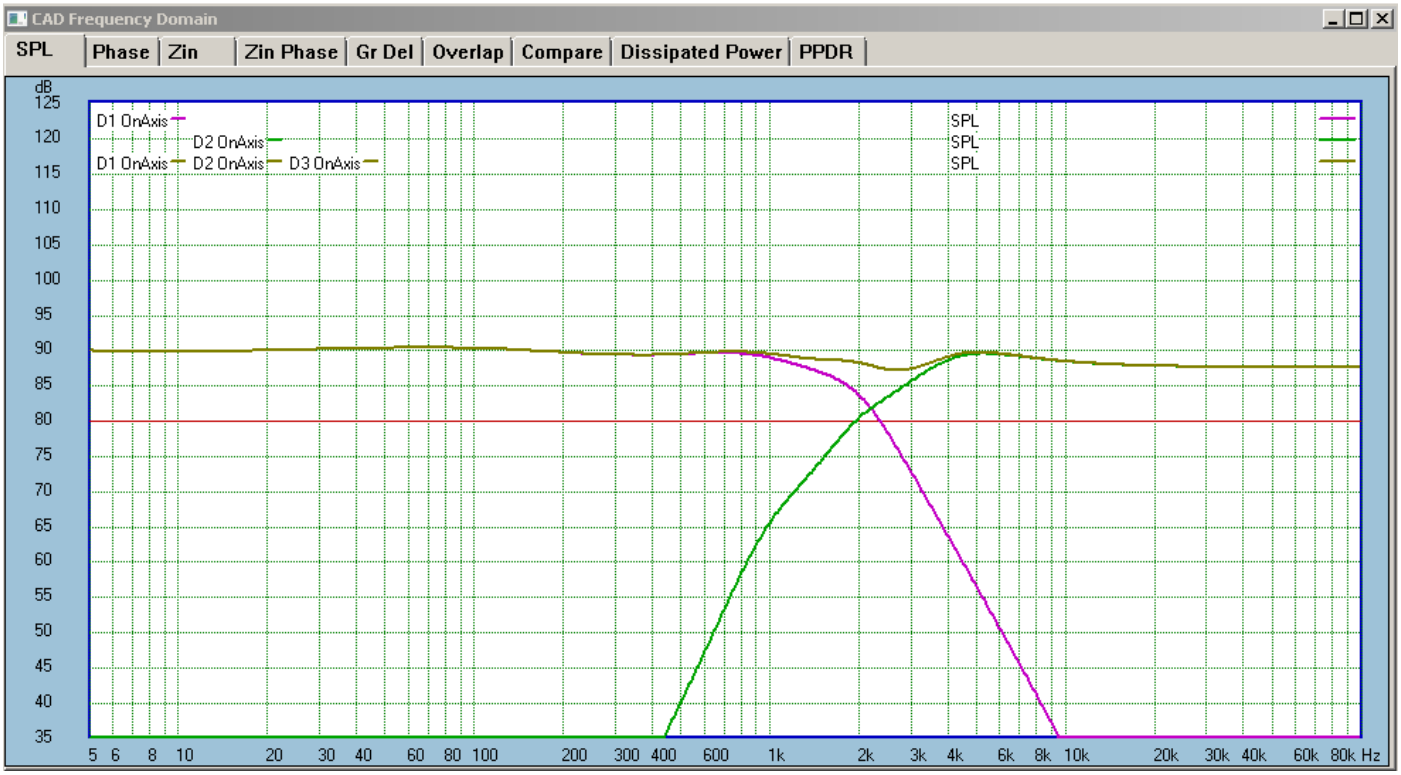


Phase Response Before (green) and After (blue)

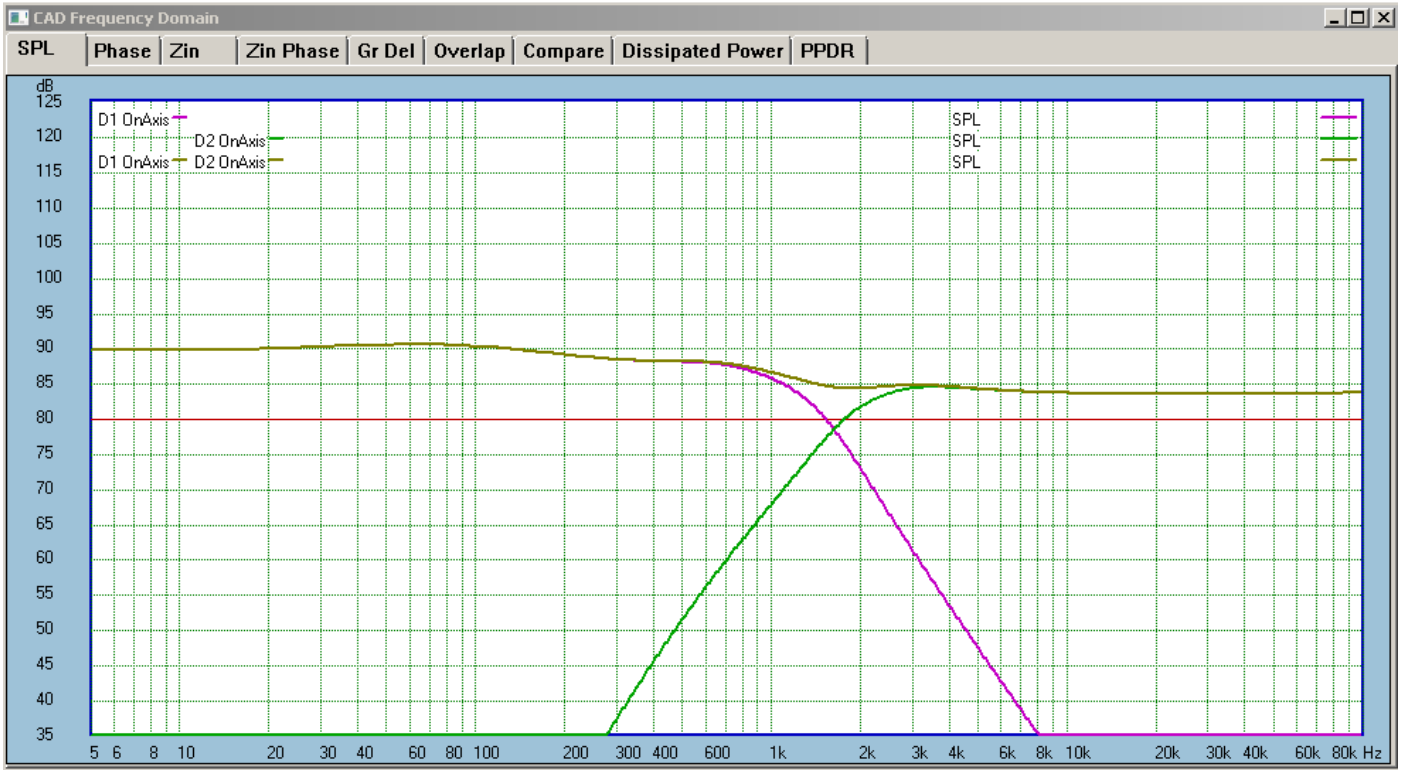


It is observable, that after the optimization, the Input Impedance (Zin) curve if flatter and the System Phase response transitions at 1500Hz – which is what is expected. Frequency response is now flat, the reverse null is sharp and almost -20dB deep.

Original Crossover



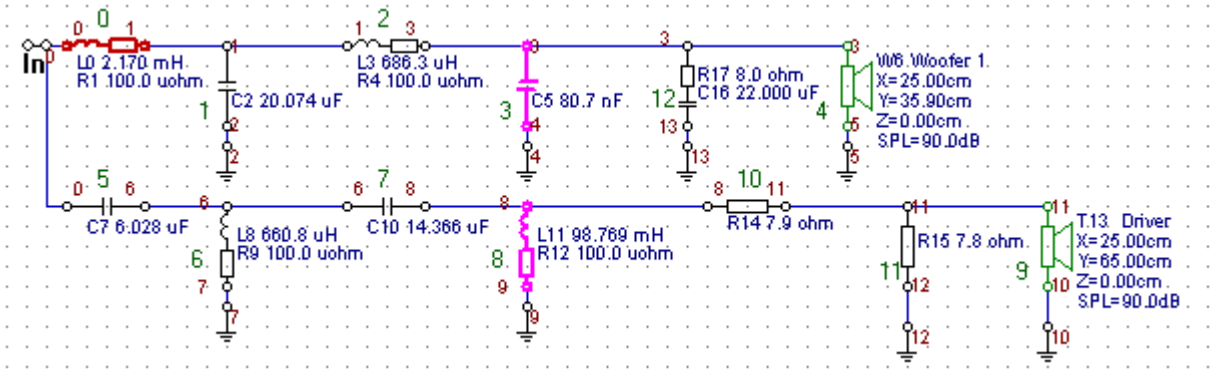
Optimized crossover

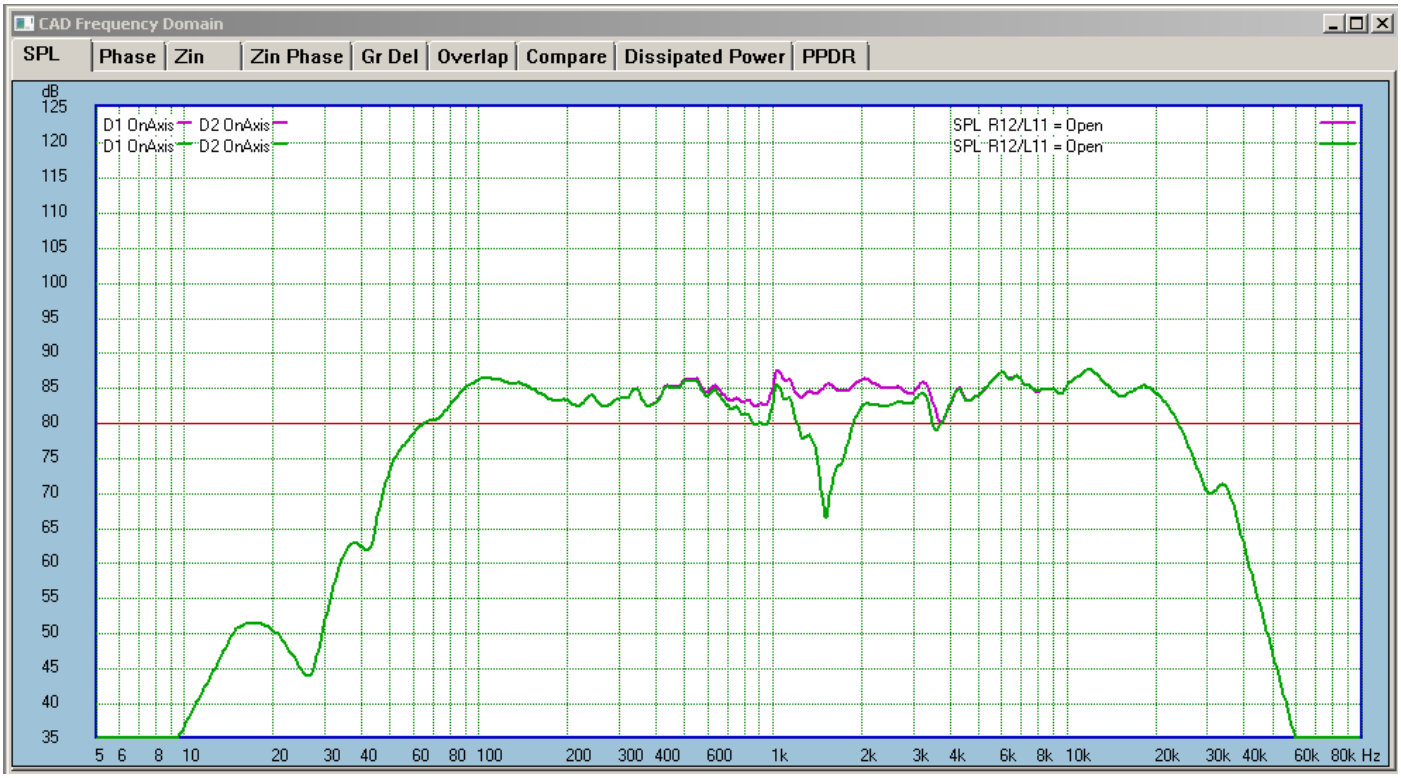


Optimizer Has Re-designed the Crossover.

C5 = 80.7nF (very small) is NOT NEEDED. When set to Open Circuit, is does not have any influence on the crossover operation.

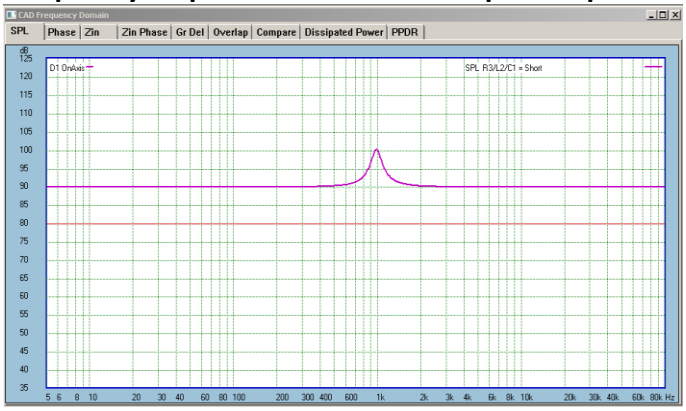
L11 = 98.8mH (very large) is NOT NEEDED. When set to Open Circuit, is does not have any influence on the crossover operation.

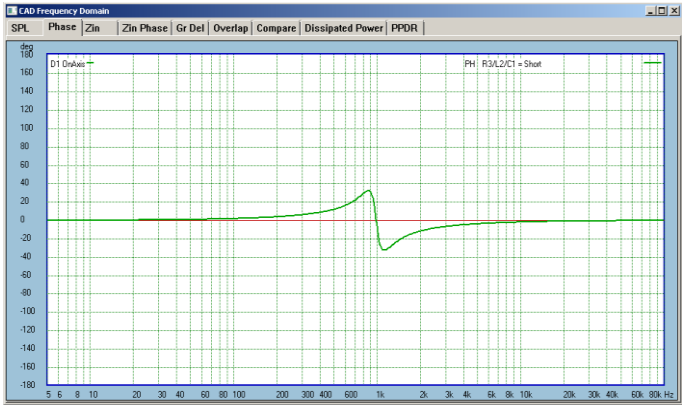


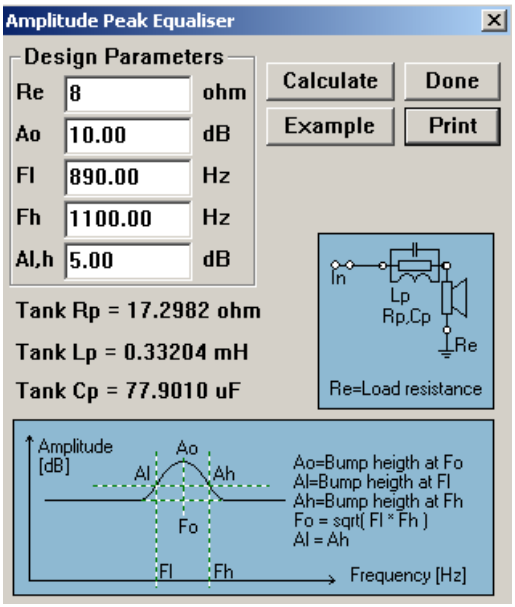


Compensating Amplitude Peak

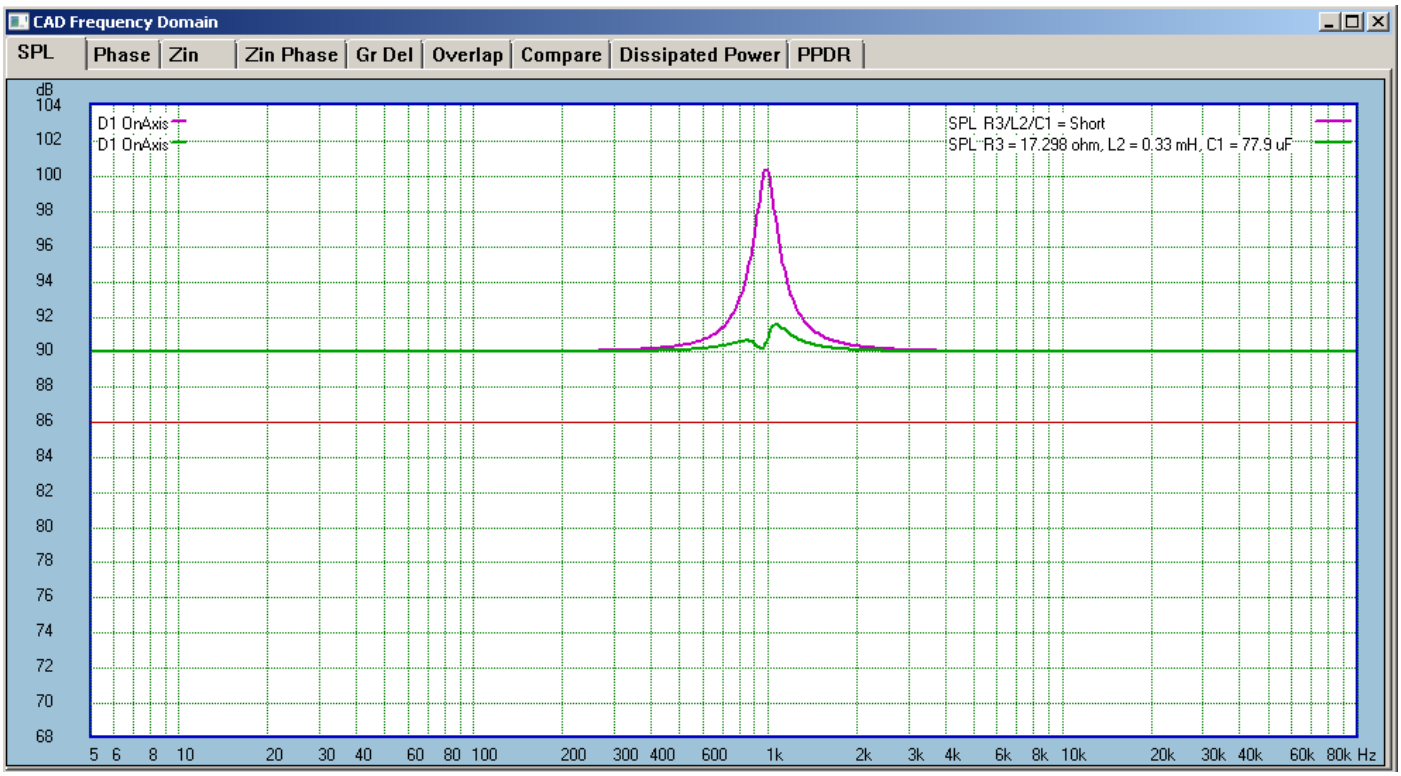
Frequency response has a +10dB amplitude peak – see figures below.



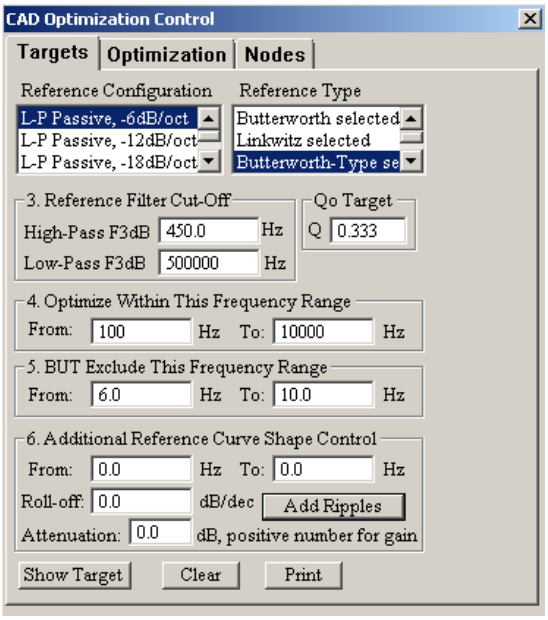




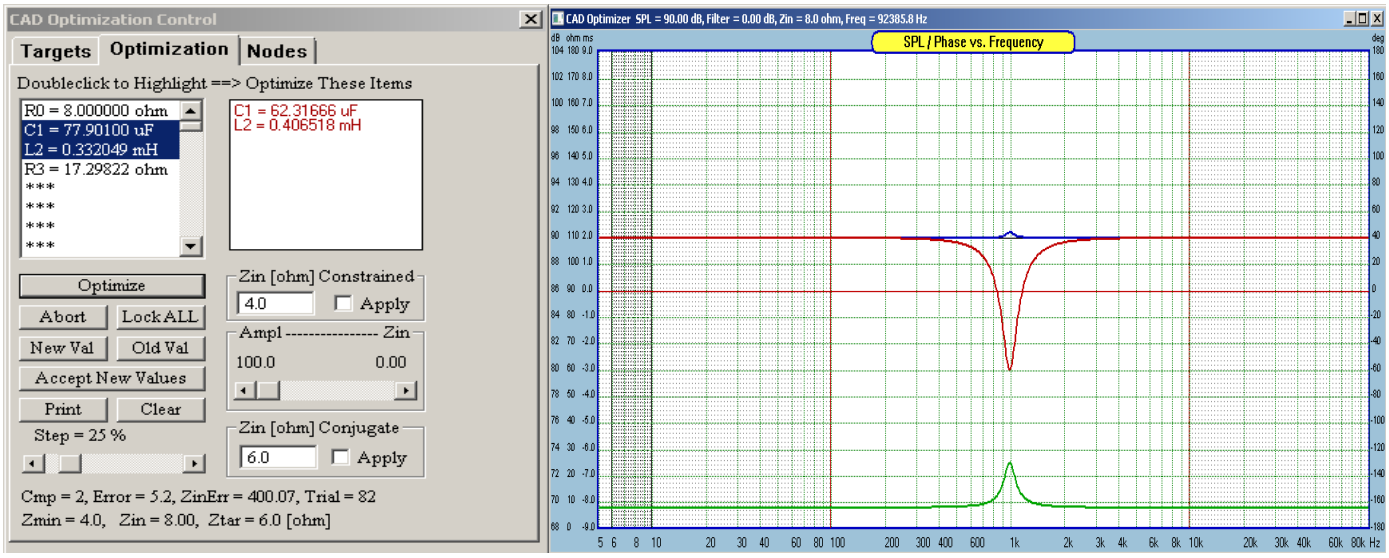
Amplitude Peak Equalizer generated component values as shown above. The peak is greatly reduced, but not eliminated.



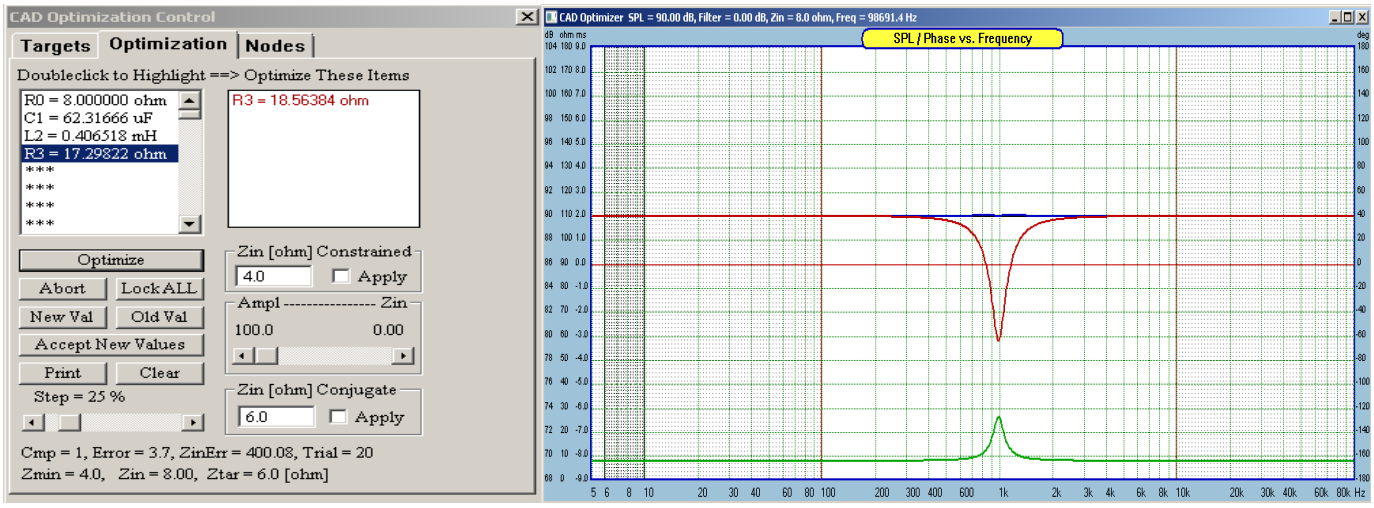
Now, the optimizer is engaged. Optimization Parameters are as follows:



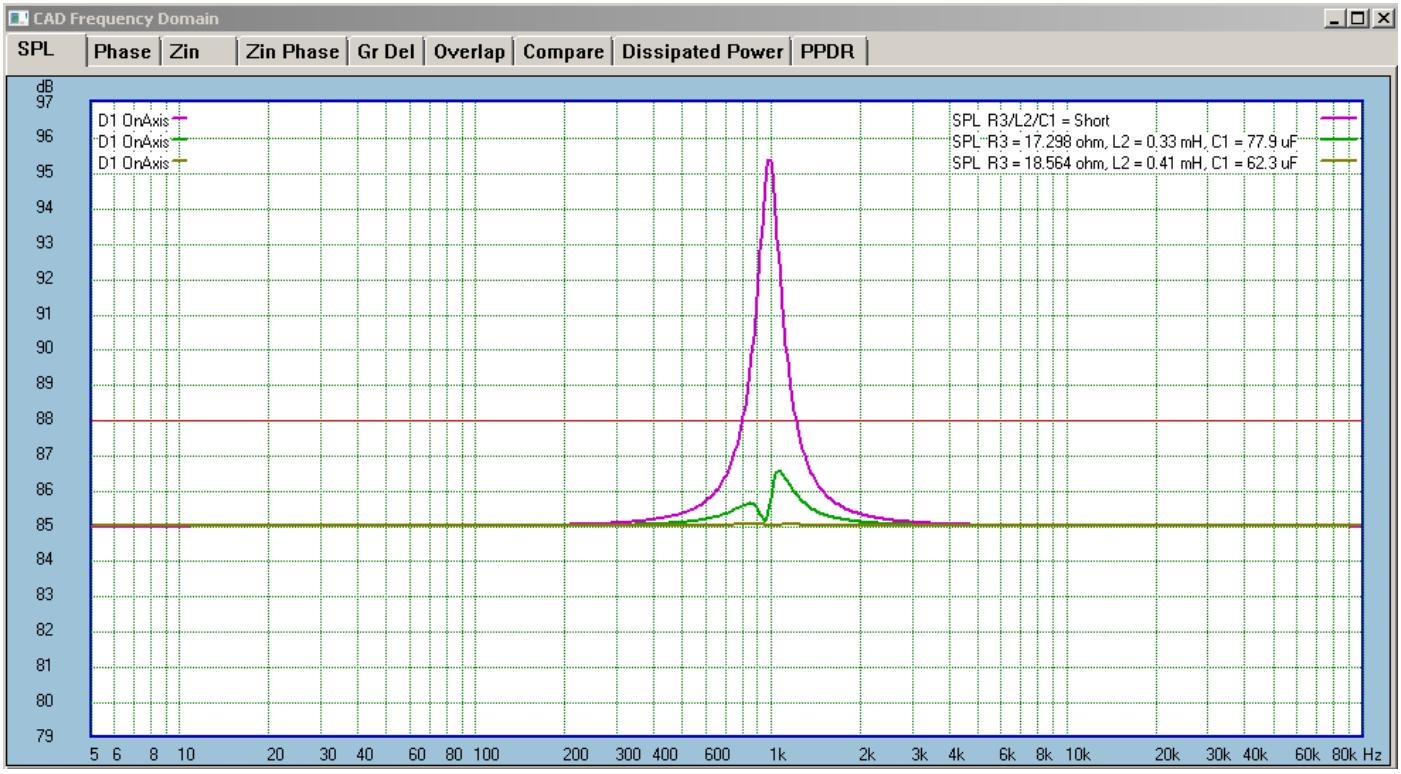
Optimization was performed in two stages. Stage 1 – C1 + L2 resulting in SPL curve improvement (blue) as shown below.



Stage 2 – R3 resulting in SPL curve improvement (blue) as shown below.



Further down are the comparison results between the values calculated by the Amplitude Peak Equalizer (green), and values optimized by two-stage optimization process (olive). Original SPL curve is pink. Please note, that the vertical resolution dB scale was set to 1dB. Otherwise, in 5dB scale, the optimized curve was a flat line.



Conclusions

1. **Loudspeaker system has been designed and optimized without single manual tweak of any component.**
2. **Optimizer handled up to 6 components at a time, even though it is not recommended to exceed 3 components.**
3. **All of the parametric performance curves exhibit good characteristics after optimization.**
4. **Optimized SPL curves for individual filters do not follow 4th order LR filters, but the acoustic responses from the drivers do. This was the design goal.**
5. **Optimizer has also eliminated two components from the crossover circuit.**
6. **Local SPL irregularities (10dB peak, for example) are also handled very well by the optimizer, using two-stage process.**