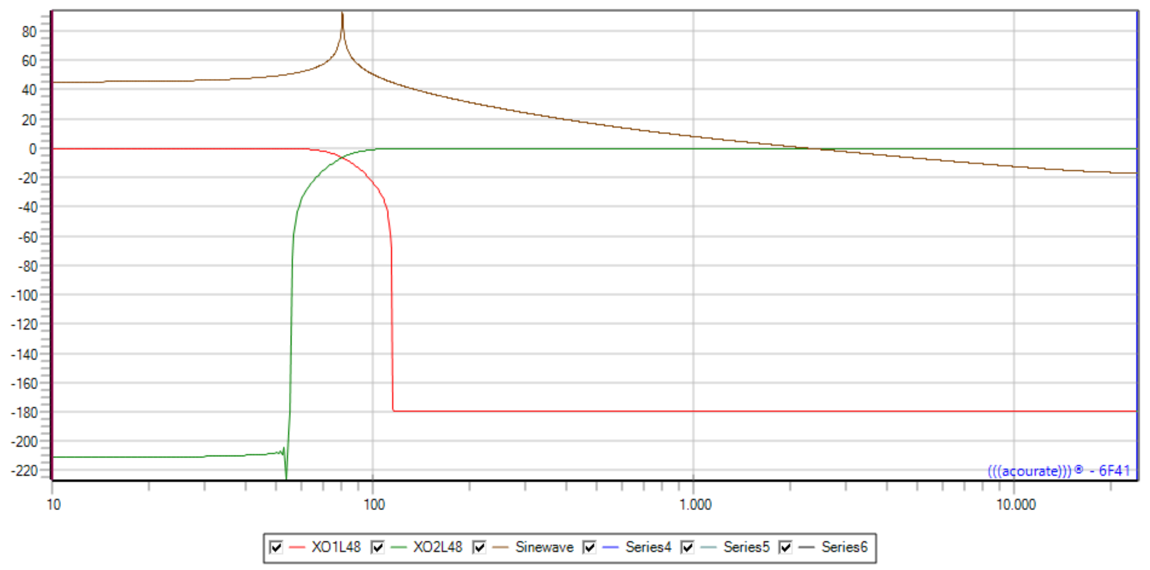
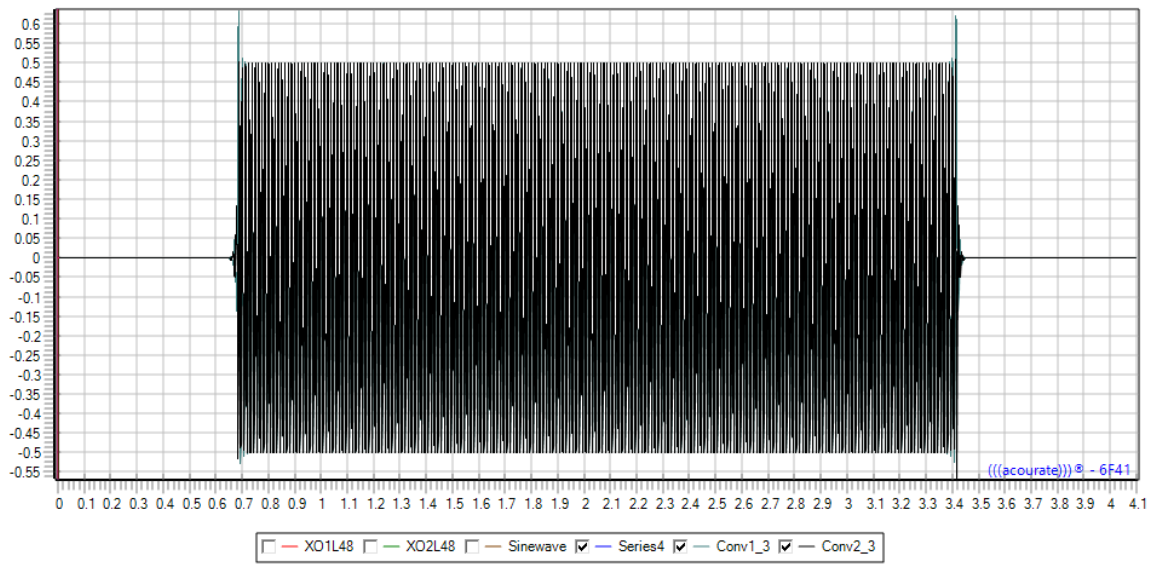
Time Alignment of Drivers by Sinewave Convolution

1. A little simulation for better understanding

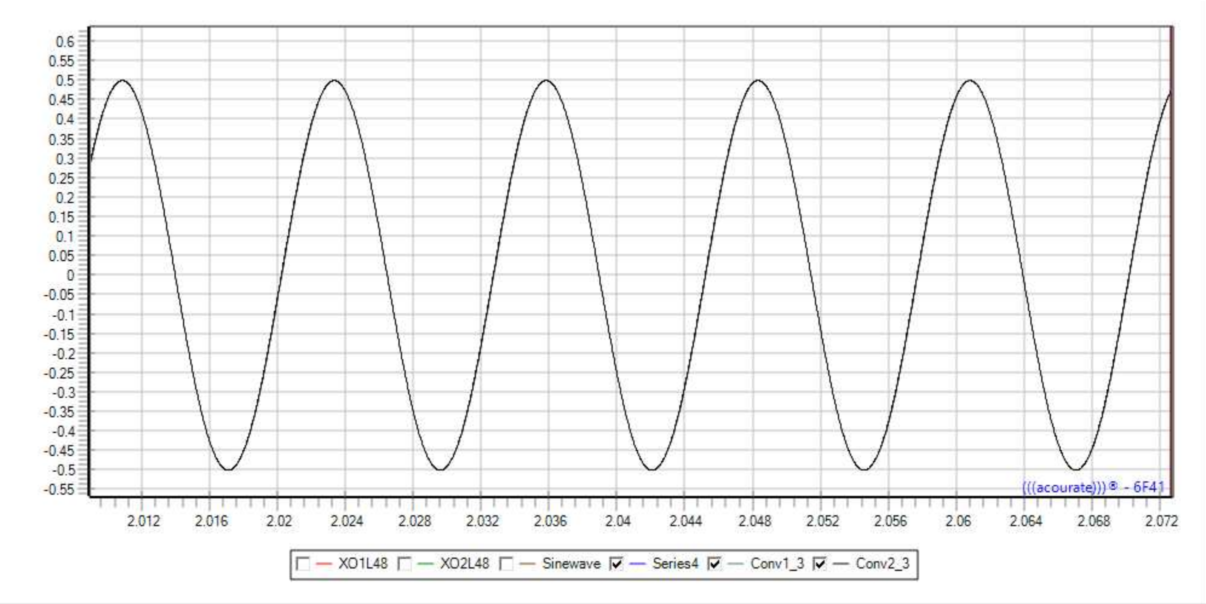


The picture shows the frequency response of a lowpass and a highpass crossover NT2 with a corner frequency is 80 Hz. Furthermore the picture shows an 80 Hz sinewave created by Generate – Sinewave – 80 Hz

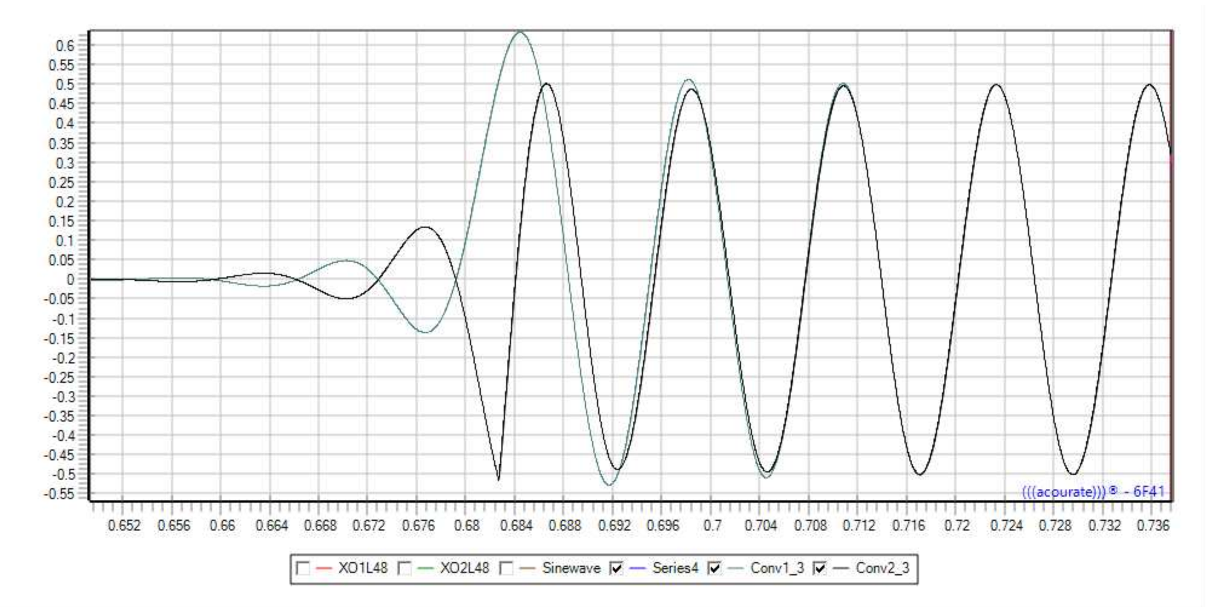
We will study the behaviour in time domain. Thus we convolve XO1 with the sinewave and we convolve XO2 with the sinewave by TD-Functions – Convolution
The result looks like



and we zoom into the picture to learn more.
There are three regions to discuss. The first one is in the center where the convolved signals reach a steady state:



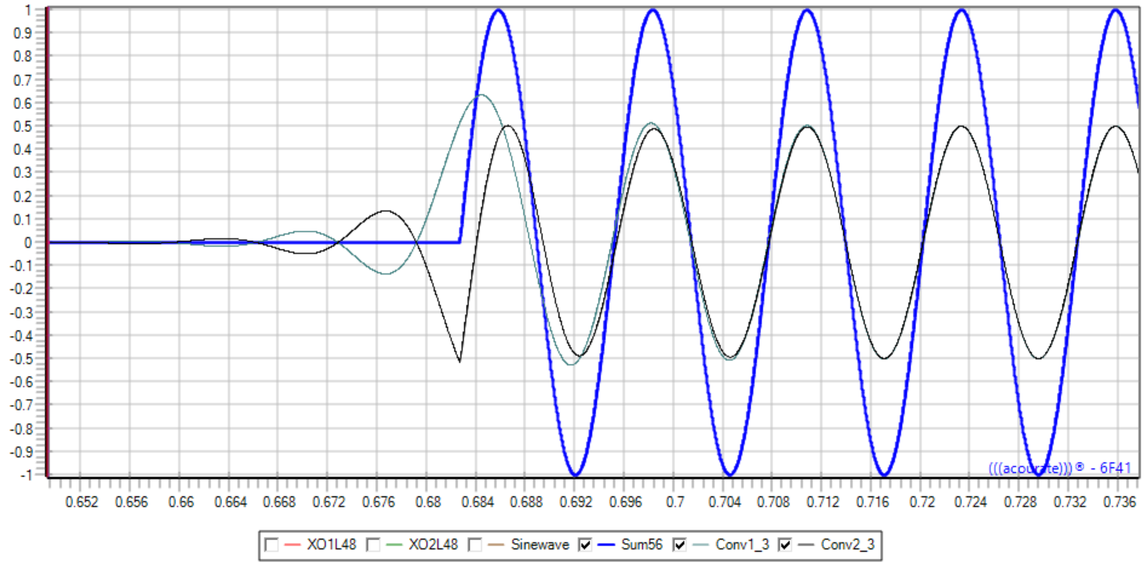
Indeed in the perfect world both convolution results match in phase (because of the linear phase filters) and amplitude (0.5 = -6 dB point @ 80 Hz). So in the steady state we expect the results to be in phase, otherwise we do not match the timing requirements.



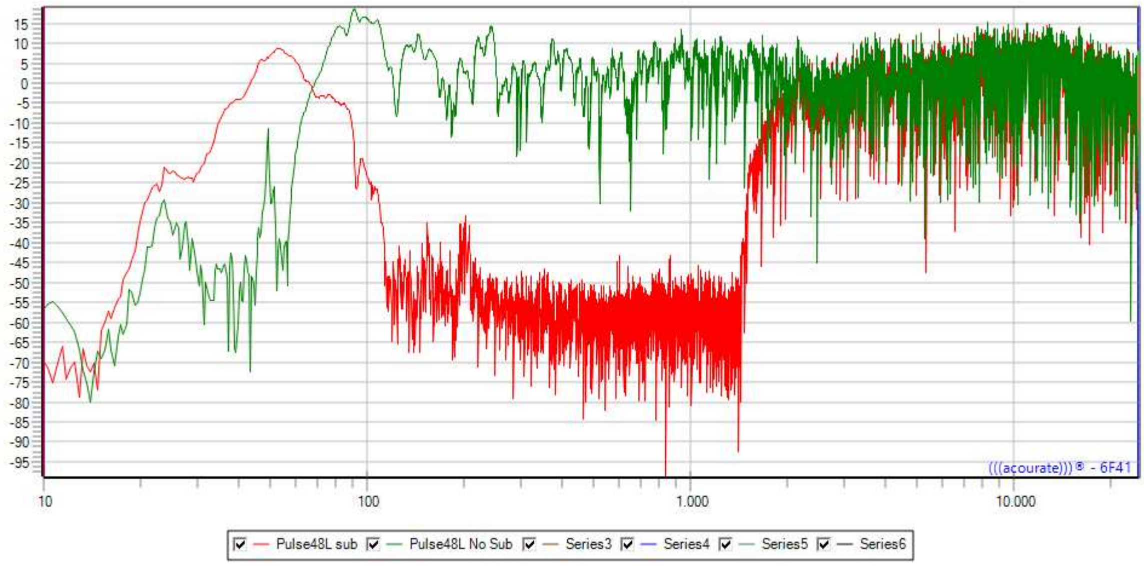
Now a zoomed picture of the behaviour at the start.
First we see at the right side both signals getting into phase = steady state.Second we see at the left side the signals behaving with opposite polarity. And third we detect a characteristic kink point with the signal resulting from the highpass – sinewave convolution (at time position ~ 0.683)

We have to keep in mind these three regions. The kink point splits the transition area in two parts, at the left the signals in opposite, at the right the signals getting more and more into phase until the steady state is reached.

The next picture shows how the signals sum up perfectly:

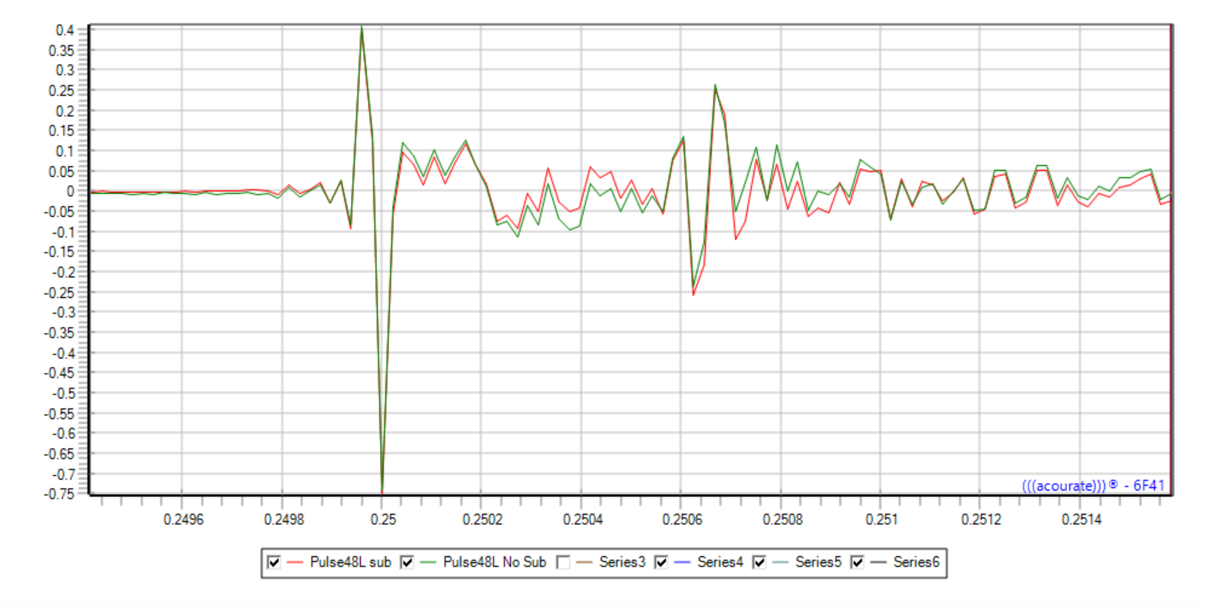


2. Reality with real world measurements

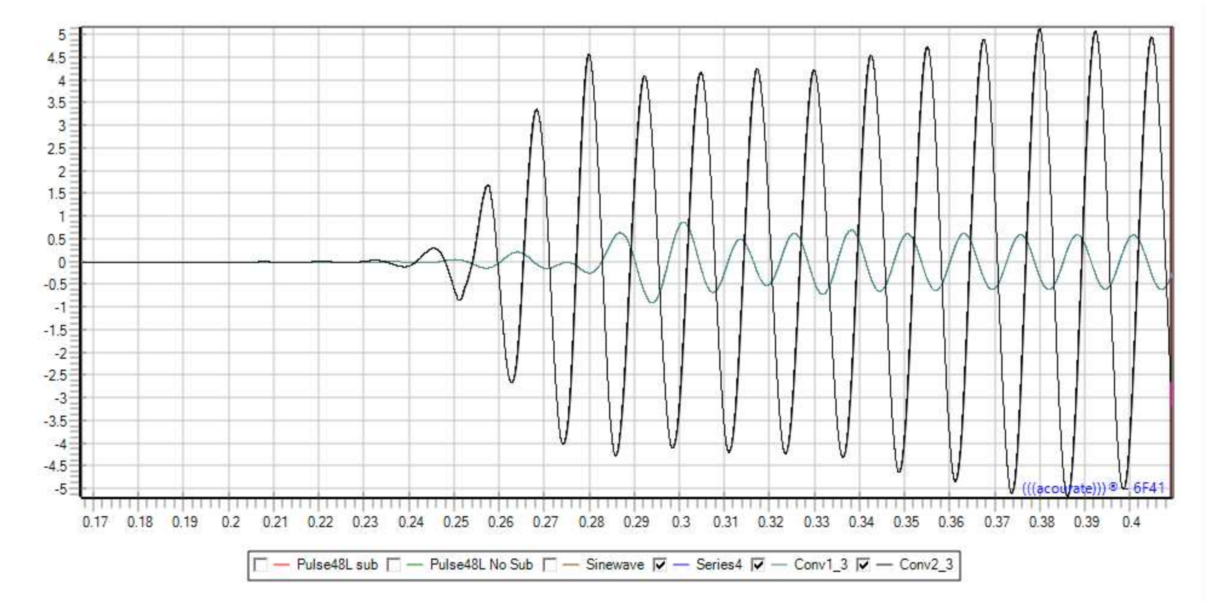


The picture shows two frequency responses. The green one is the main speaker without subwoofer. The red one is the subwoofer plus the main speaker treated by a highpass. This allows the pulse responses to be perfectly time aligned by the high frequency content in the responses. Because the high frequency content creates a peak with a high amplitude.

This is demonstrated by the next picture in time domain:



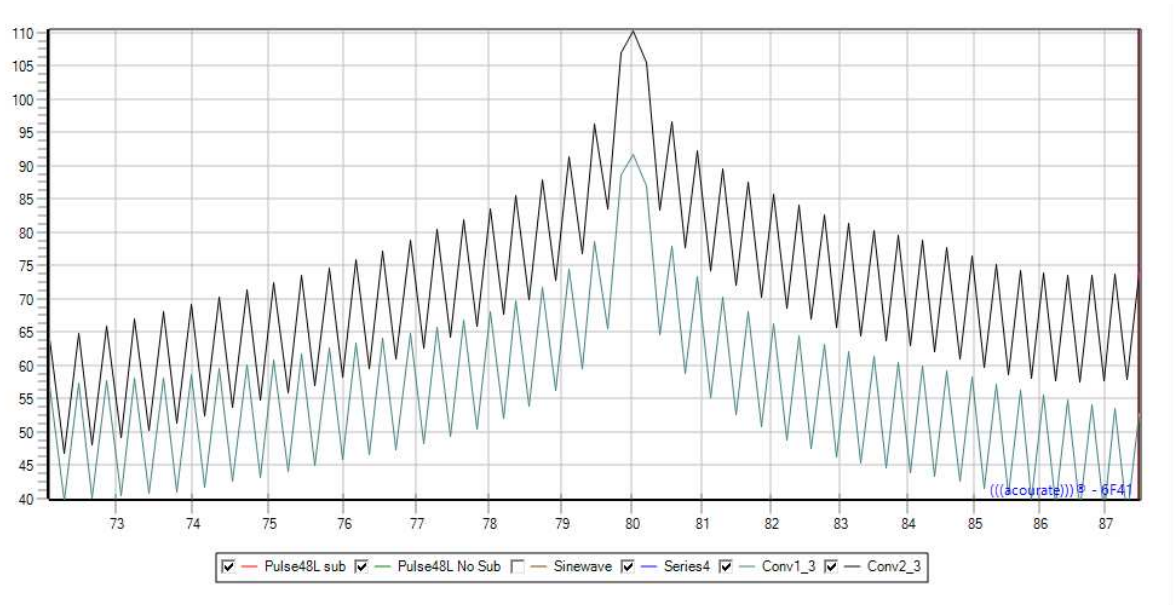
Now we can convolve again both pulse responses with the 80 Hz sinewave and we get a zoomed picture



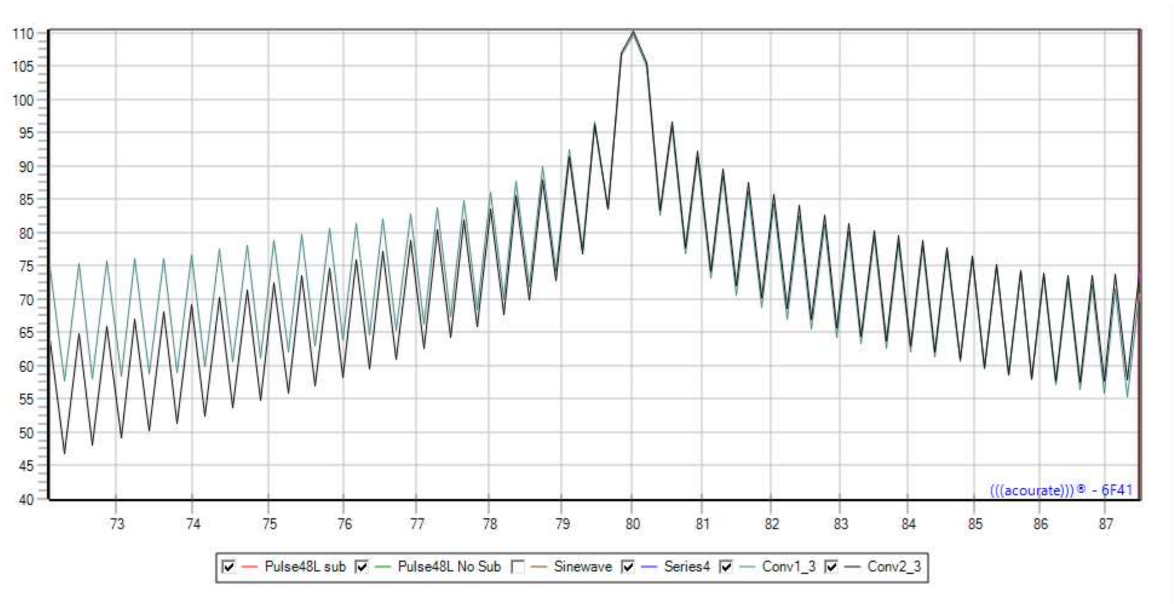
Well, we clearly recognize a pretty low signal amplitude of the subwoofer in comparison to the main speaker. A first approach would be to adjust the gain of the subwoofer in relation to the main speaker, if possible. We can even adjust this by applying some gain to the measurements.

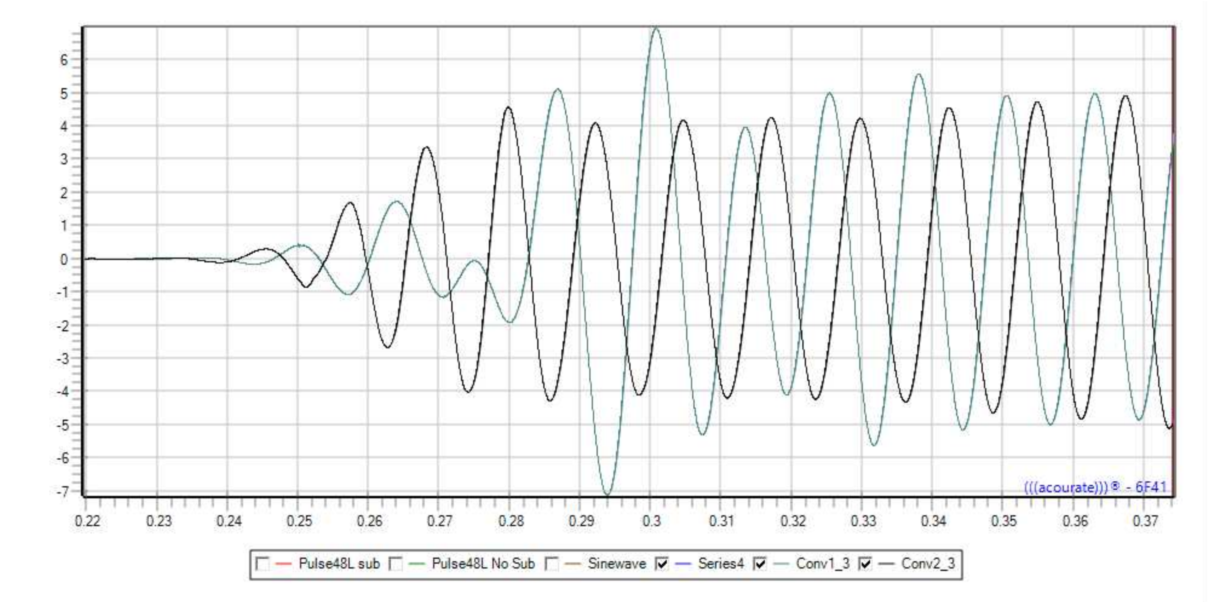
We also detect that the signals are different in phase and the subwoofer seems to be delayed. So first we investigate if we can improve the first left part of the transition area where both signals should run in opposite polarity.

So we can rotate the sub signal to the left (taking the main speaker as master) and we can even switch the sub polarity if appropriate.

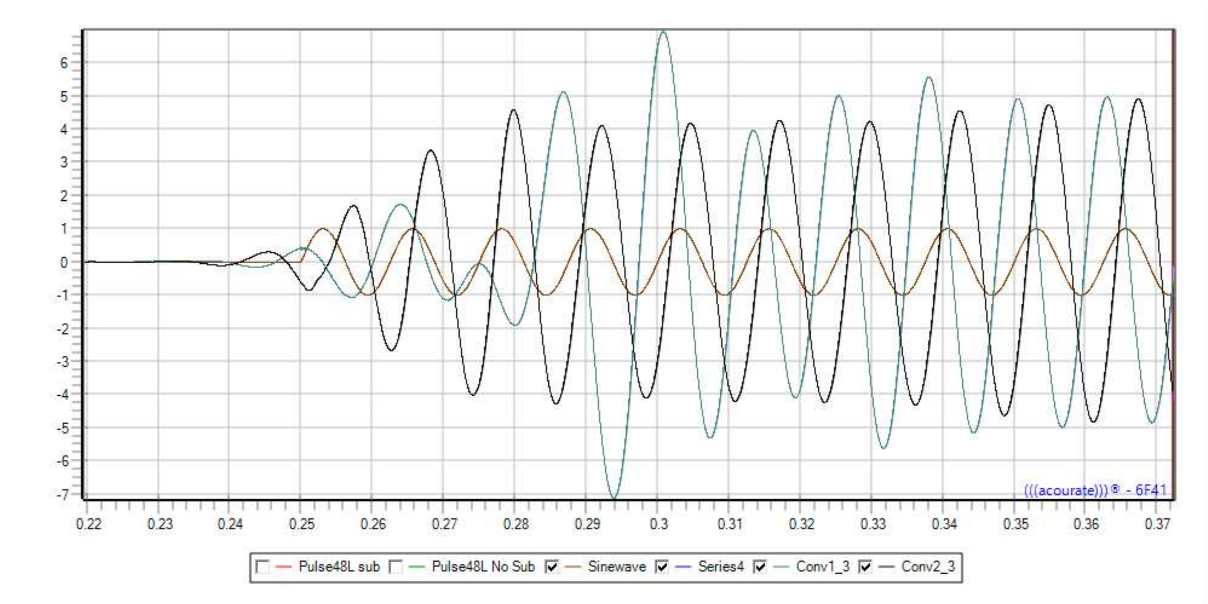


A zoom of the frequency shows that the sub signal is about -18 dB lower. So we apply a gain of 18 dB and get

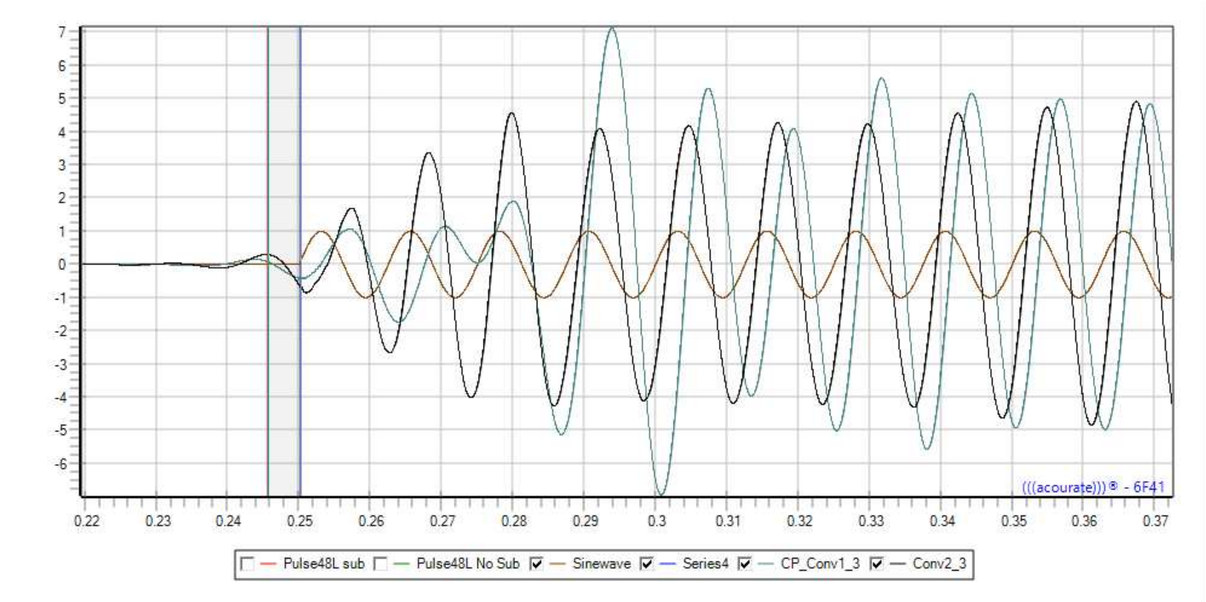




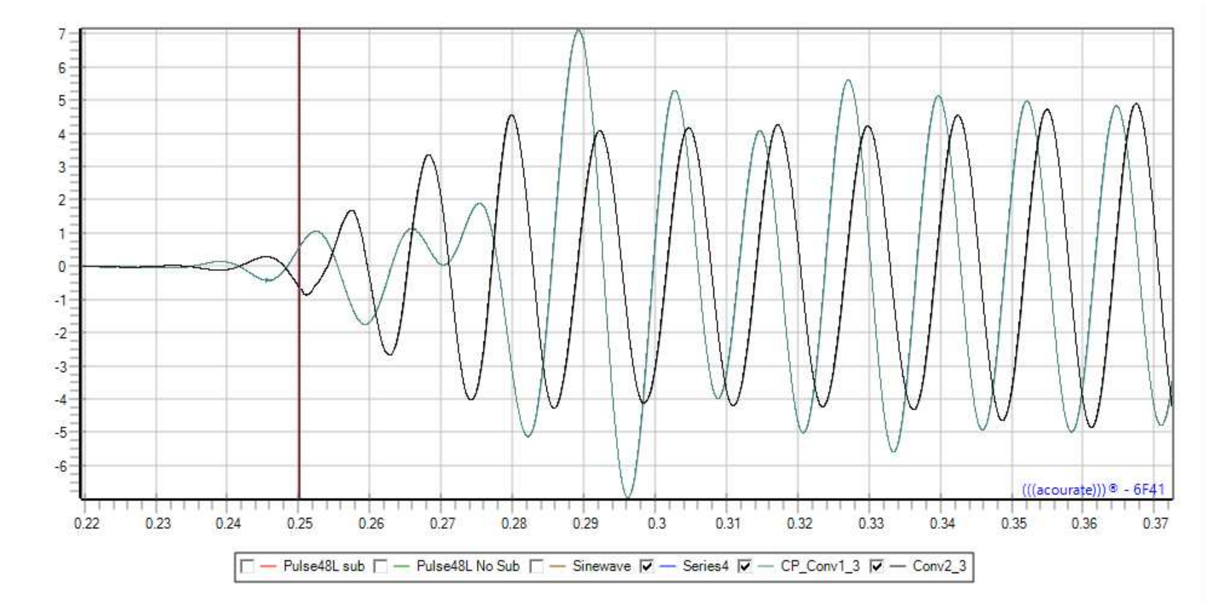
As the max peak of the main speaker is at position 12000 we add some leading zeros to the 80 Hz sinewave to see the optimal start point.



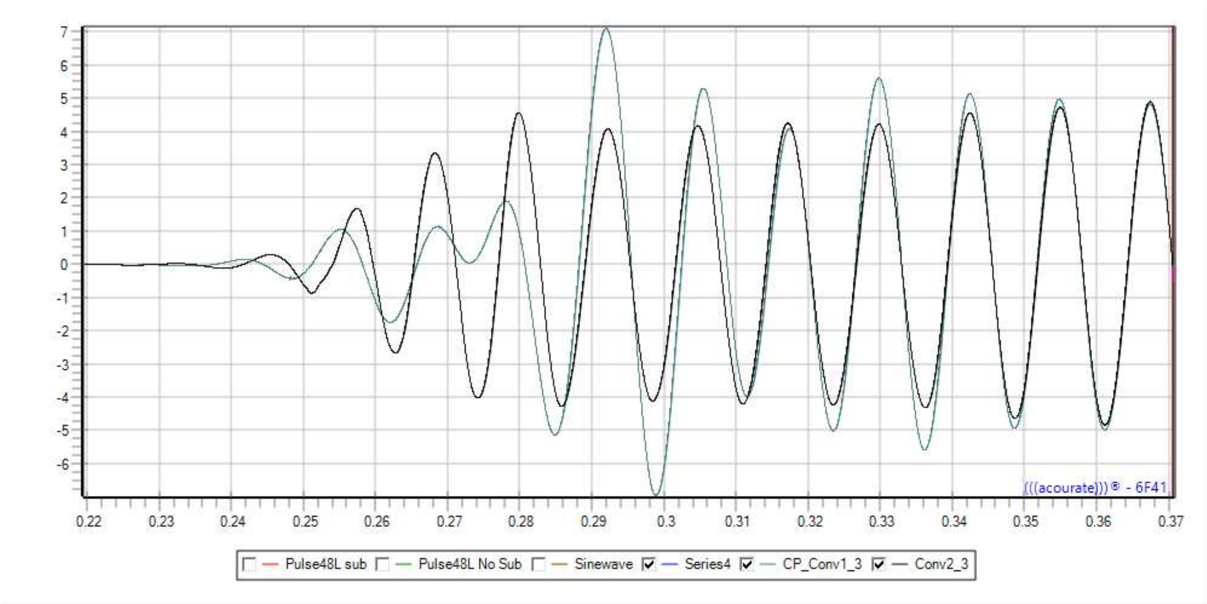
Switching the polarity of the sub by TD-Functions – Change Polarity results in



The left marker shows the positive peak of the main speakers left transition, the right marker shows the negative peak of the sub. We expect the left transition zone to be in opposite.
The distance is about 225 samples. Thus the sub gets a rotation by -225 samples. This leads to a new picture



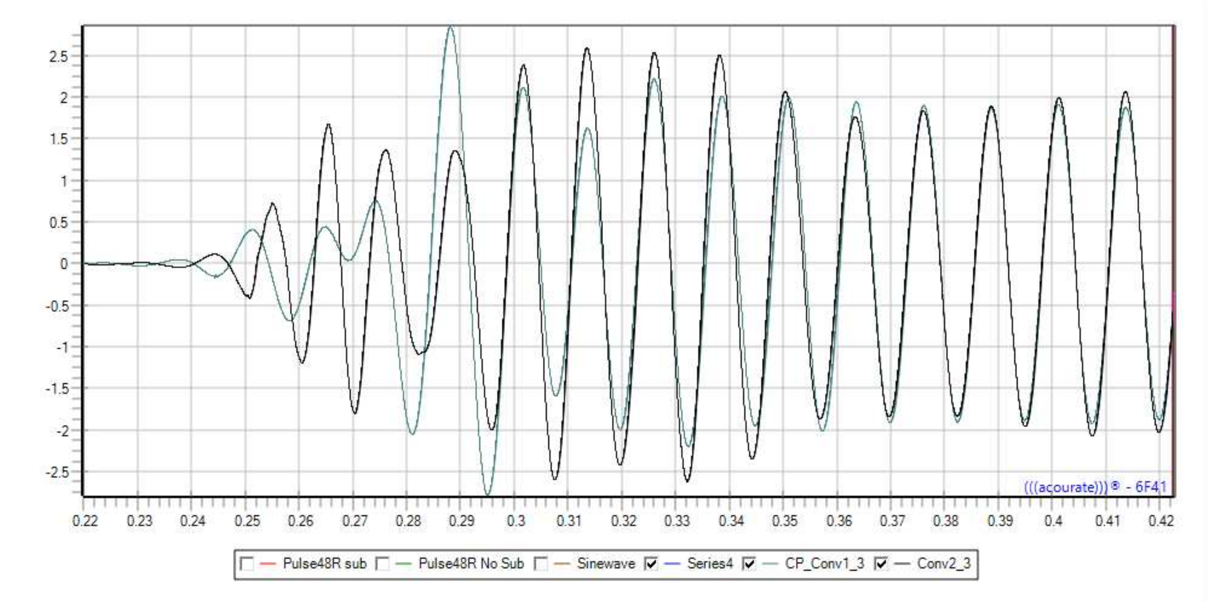
This definitely looks better for the expected transition zone.
But now we also detect that the steady state behaviour is not optimal as the signals run out of phase.
We also see some reflection influence at time ~ 0.27.
So we must make a decision about a compromise. We can rotate the sub by 131 samples to the right and get



So in the steady state sub and main speakers are running together. But at the very first start we do not get the transition that we like to have.

Ok, here for the left speaker and sub we get a result by switching the polarity of the sub and by playing it in advance of -225 + 131 = -94 samples.

Let’s study the right sub and main speaker:



The picture shows the result with the sub polarity switched again and playing the sub 277 earlier than the main speaker.
Here the transition area looks better.

So the final decision for the given example is to

- switch the polarity of the subwoofers
- rotate the left sub XO1L by -94 samples
- rotate the right sub XO1R by -277 samples