3. Measure response, set gains for each driver, determine delays for each driver go back and adjust XO frequencies to give smoothest result while taking advantage of "acoustic crossover" of the drivers.
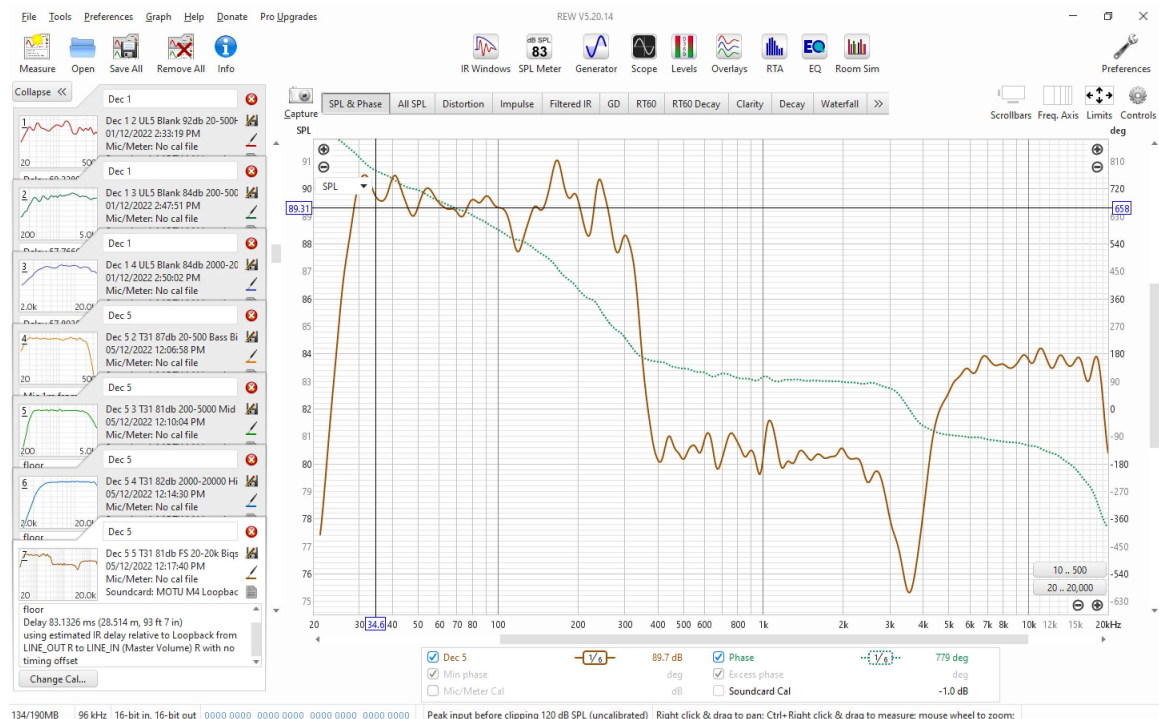
This measurement shows a Full System 20-20,000Hz SPL and lets us determine the gains needed. I will leave Hi as is, drop Bass and lift Mid

Driver SPL   Adjustment needed

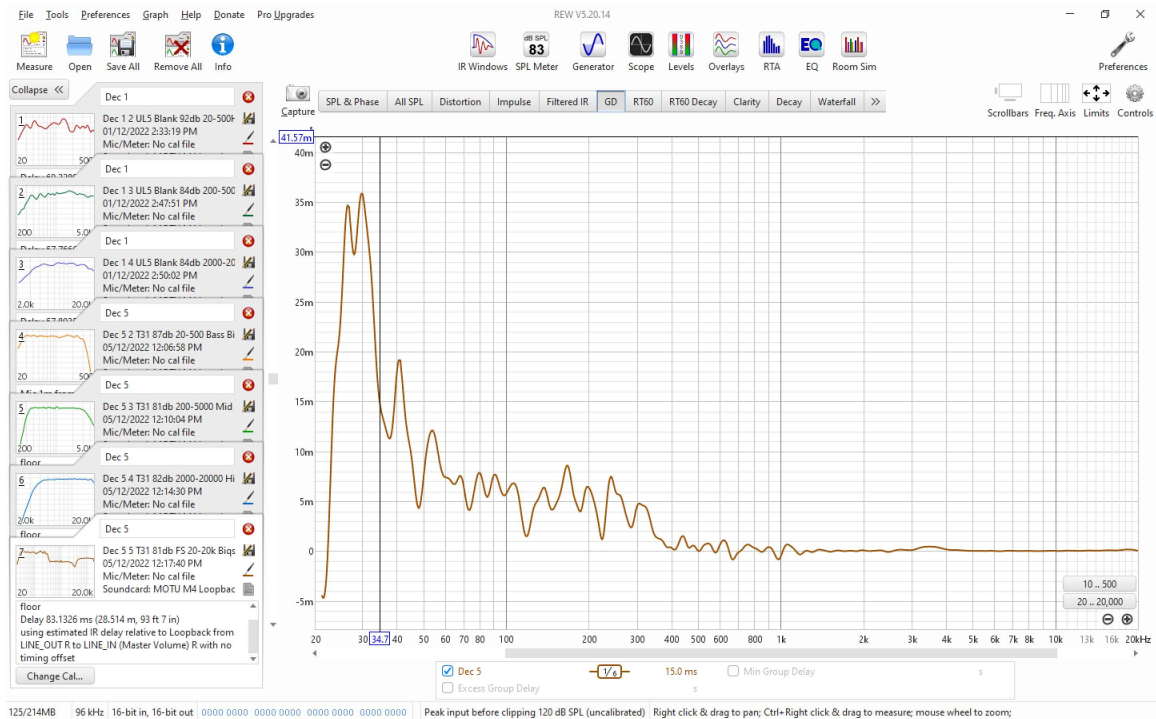Bass   89.45db   -5.8db

Mid   80.3db   +3.3db

Hi   83.66db
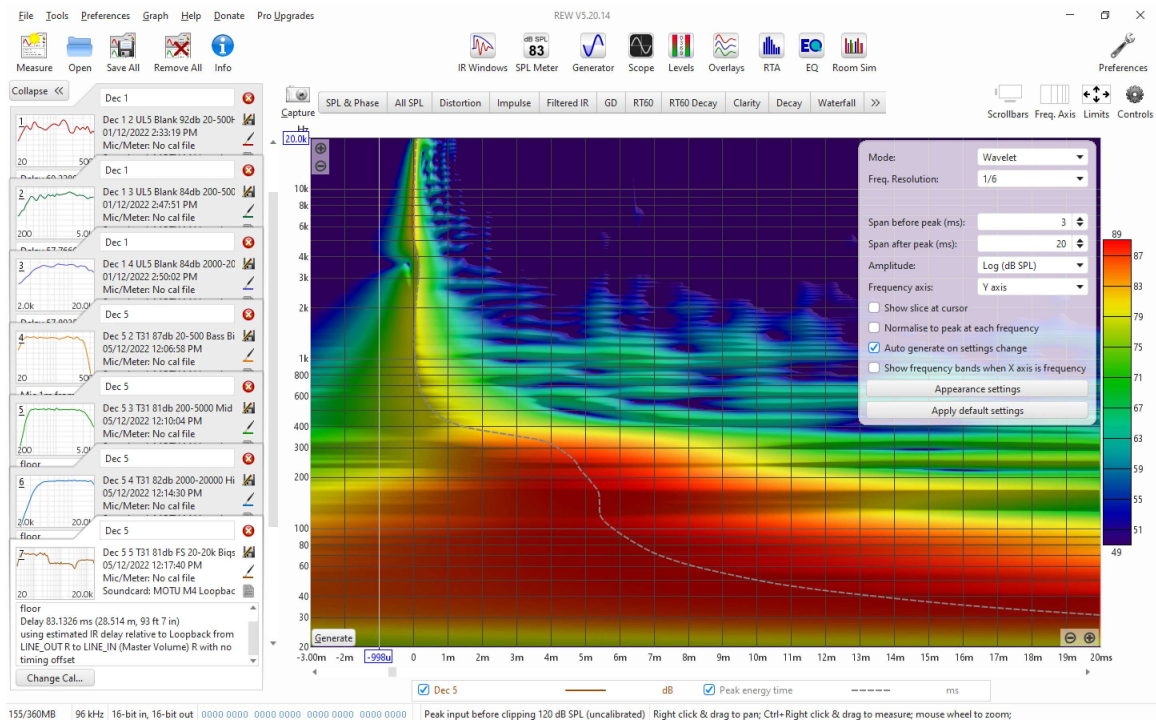

Dec 5 5 T31 81db Fs 20-20kHz Biquads and XOs.jpg

If we leave the Hi alone, we need to raise the mid by 3.3db and lower bass by 5.8db. So in CamillaDSP we add two filters Gain +3.3db and -5.8db and add them to the Pipeline.

Delay - here is a REW GD plot showing the Mid & High on 0ms and Bass arriving 5ms later
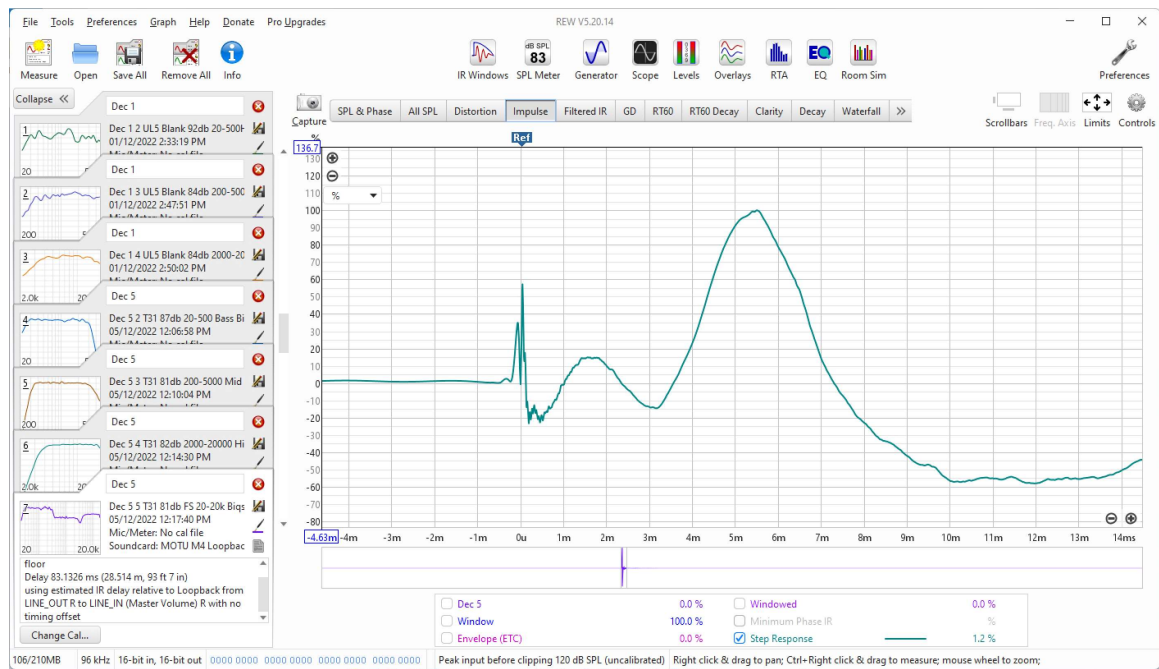
Dec 5 5 T31 81db Fs 20-20kHz Biquads and XOs Group Delay.jpg

and a REW spectrogram showing the same delay

Dec 5 5 T31 81db Fs 20-20kHz Biquads and XOs Spectrogram.jpg

The Impulse response

Dec 5 5 T31 81db Fs 20-20kHz Biquads and XOs Impulse.jpg

The SPL and Spectrogram plots show stuff happening at 3600Hz which is the XO frequency between Bass and Mid, the big dip at 3600Hz is classic indicator of out of phase drivers with the responses subtracting from each other.

In CamillaDSP we make a Delay filter for 5ms and add it to the Pipeline for Mid and Hi.

Time for a Full System (FS) sweep with the gains and delays.

This plot shows 3 sweeps, Bass - Orange, Mid - Green, Hi - Blue overlaid on a FS 20-20kHz sweep (Brown) before gains are adjusted and a second Full System 20-20kHz with gains.Note the out of phase dip between 3k and 4kHz.

Dec 5 6 T31 84db Gains Biquads XOs.jpg

After adding a filter in the pipeline to invert phase for Hi, here is a Full System sweep. SPL is good, but Phase is indicating a 180 drop after 200Hz to 800Hz.
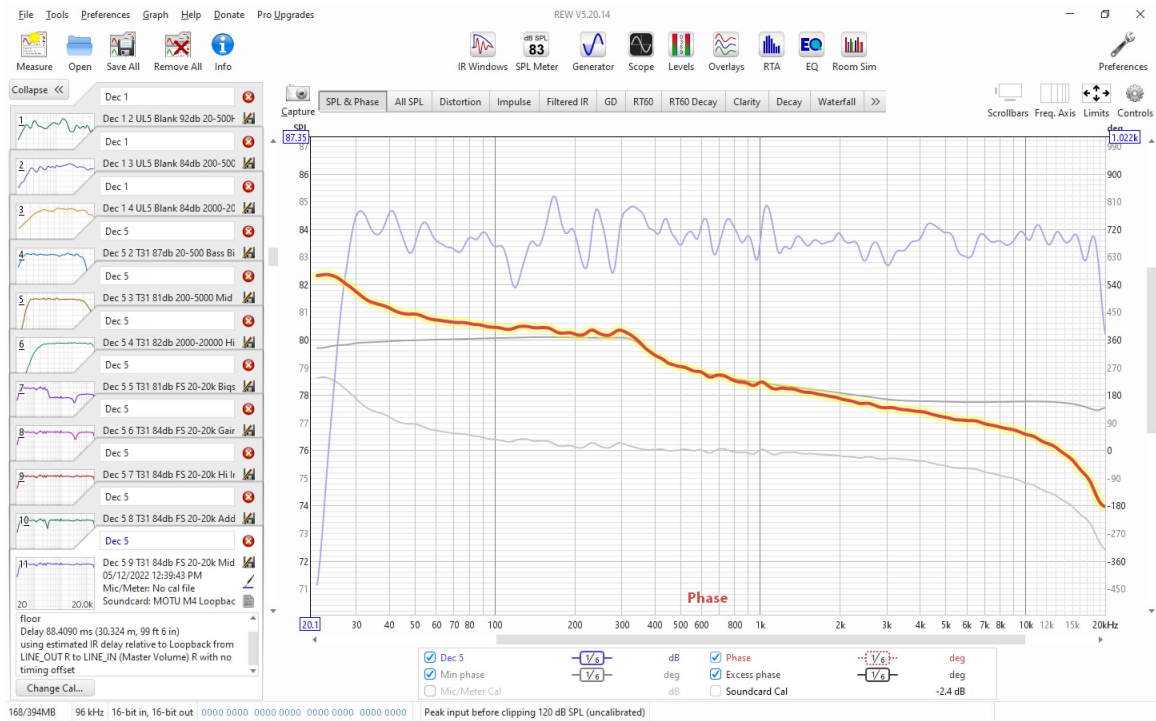
Dec 5 7 T31 84db Gains Biquads XOs Invert PH for Hi.jpg

So now a 5ms Delay filter is added to the pipeline for Mid and Hi and Full System sweep made that shows a Bass and Mid/Hi are out of phase.
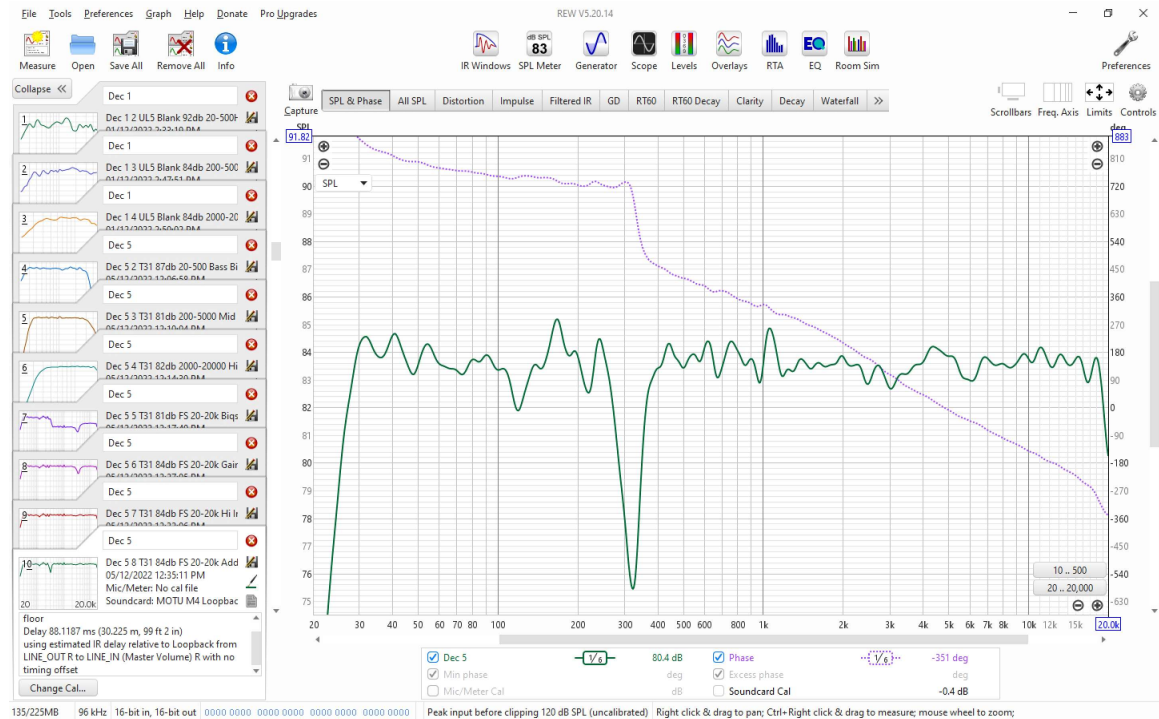
Dec 5 8 T31 84db Gains Biquads XOs 5ms delay for Mid and Hi.jpg

So I just moved the Invert Phase filter between Mid and Hi to be between Bass and Mid in the pipeline.

Dec 5 9 T31 84db Gains Biquads XOs 5ms delay and Inv Phase for Mid and Hi.jpg