Tweaking Phase Response with FIR Filters

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This article is a subset of a webinar about Loudspeaker Optimization using FIR filters. Originally presented in March 2021.

FIR filter, advantage:
Create mag and/or phs correction independently

FIR filter, limitations:
May introduce processing delay
Not effective for low frequency

Magnitude correction

- Very straight-forward.
- Easy to hear.
- Meaningful correction.

Phase correction

- Why FIR filter is popular.
- Meaningful correction?
- Can you hear the correction?

Loudspeaker in use: Community RS jr

Measurement was conducted outdoor as shown in the left picture.

Mic location: 2m away, 1.6m above the ground, on-axis to the tweeter.

Tech Info: Dual FFT using EASERA, Window length is approx. 7ms, FIR filter is created using Filter Hose. Convolution is created using GratisVolver. Wave Editor: Nuendo 11.

A change in the phase response:

> Change the waveform shape

> Impulsive sound gets tighter (hard to hear and subjective!)

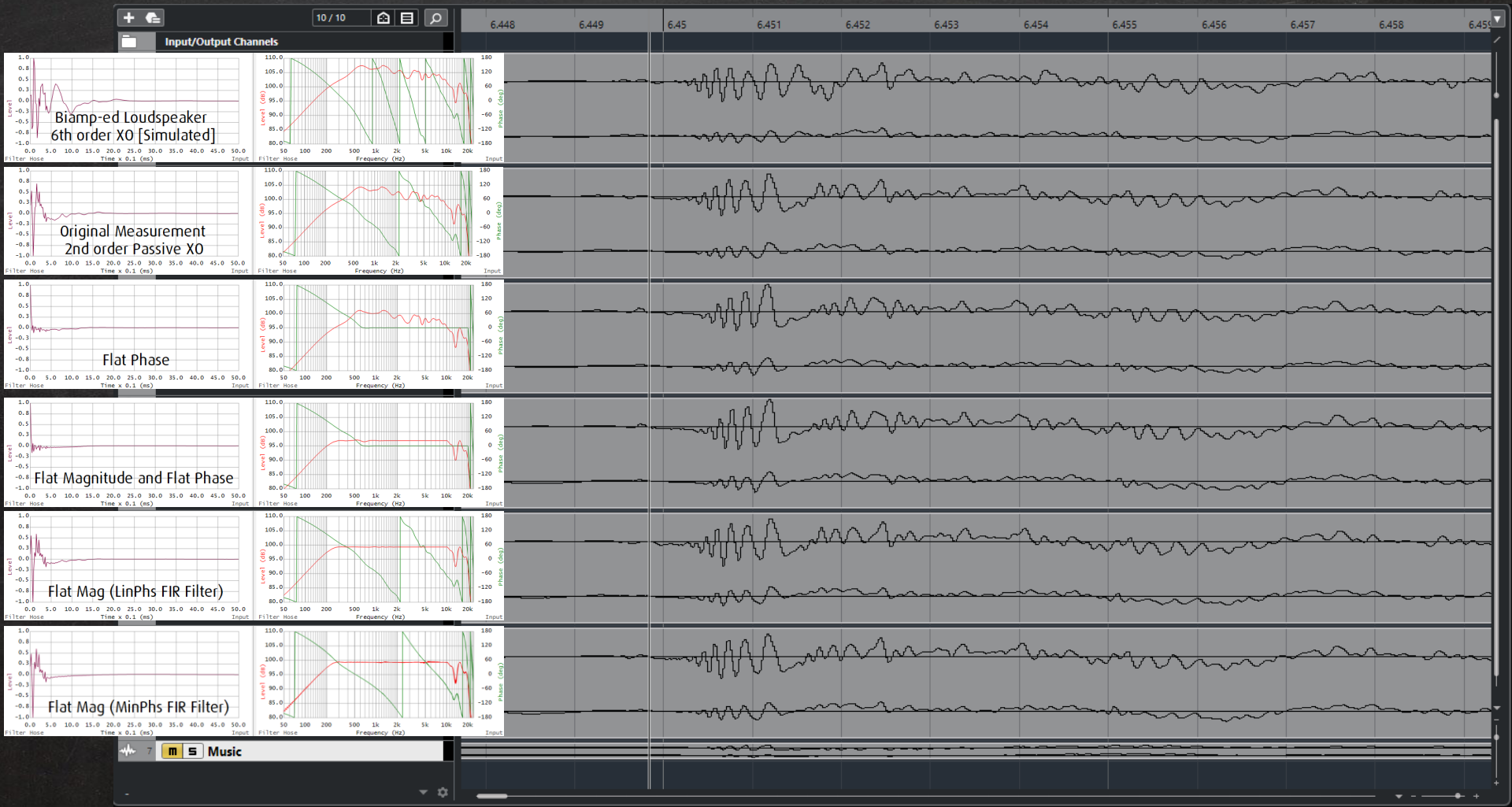
> Stereo image gets better (hard to hear and subjective!)

> Easier to hear with drastic phase change (ie. 6^{th} order to flat phase)

> Does it matter?

Next slide: comparison of waveform with different transfer functions. Please note the difference of the waveform when the phase response is different.

Loudspeaker Correction



Please use Headphones!

Click on the loudspeaker icons to play the sound.

PDF: Use Adobe Reader

PPSX: Requires Office 2016 or newer

Listening 1

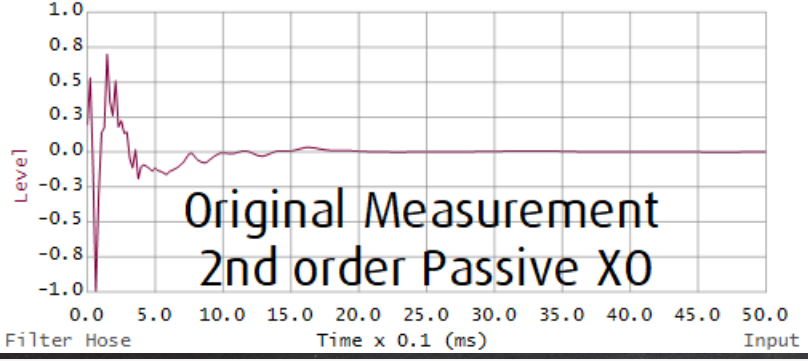
Original Response

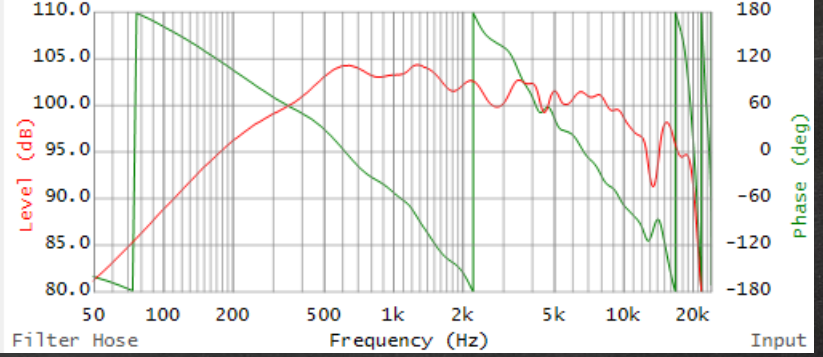
vs

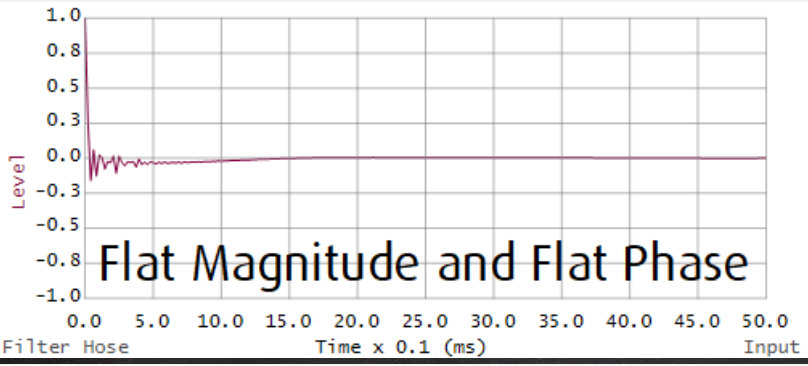
Flat magnitude & phase

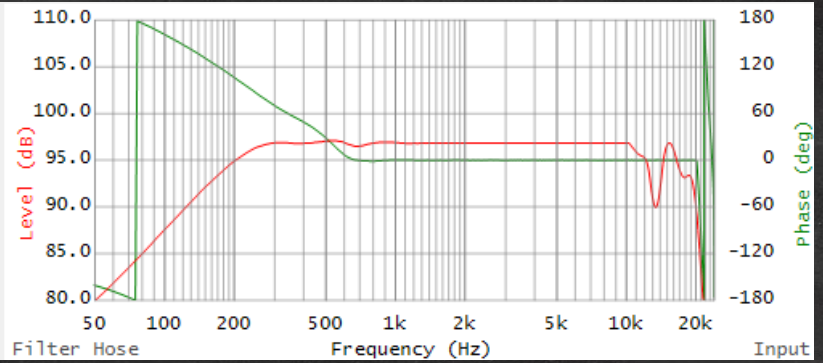
vs

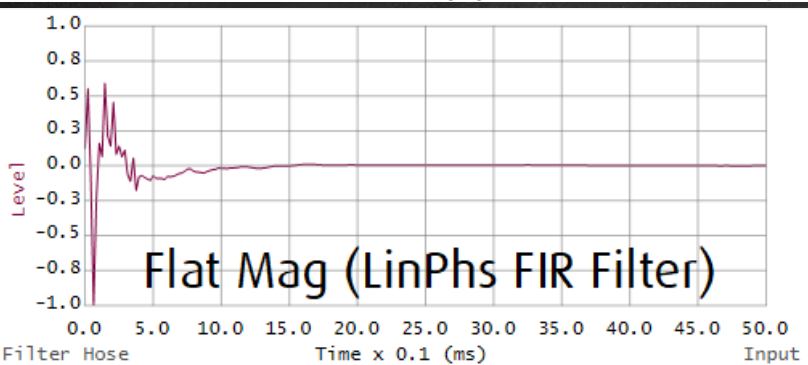
Flat magnitude only

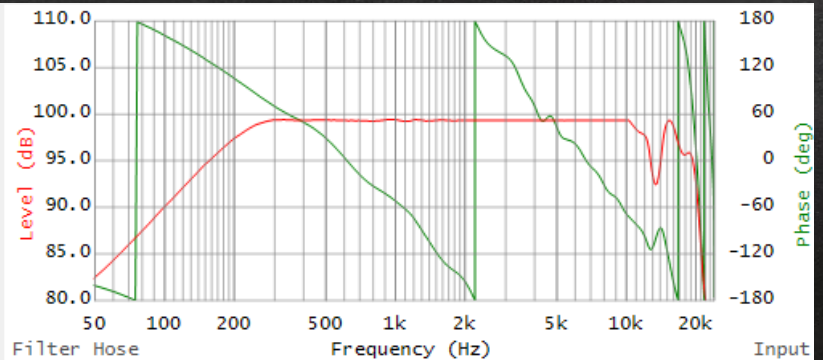

Original Measurement
2nd order Passive XO
Level
Time x 0.1 (ms)
Filter Hose
Input


Level (dB)
Phase (deg)
Frequency (Hz)
Filter Hose
Input


Flat Magnitude and Flat Phase
Level
Time x 0.1 (ms)
Filter Hose
Input


Level (dB)
Phase (deg)
Frequency (Hz)
Filter Hose
Input


Flat Mag (LinPhs FIR Filter)
Level
Time x 0.1 (ms)
Filter Hose
Input


Level (dB)
Phase (deg)
Frequency (Hz)
Filter Hose
Input

Listening 2
(Same magnitude, different phase response)

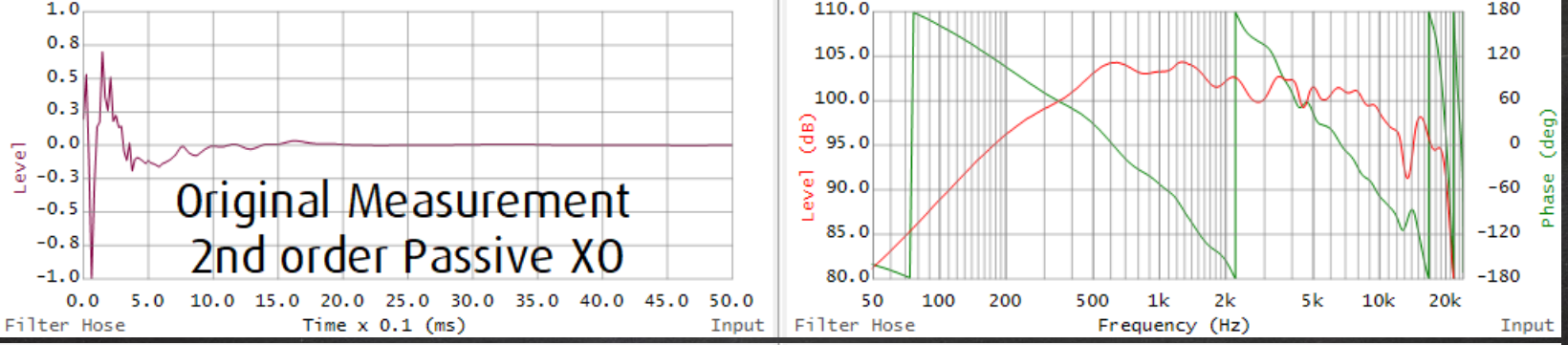
Original Response
(Passive Crossover 2nd order)

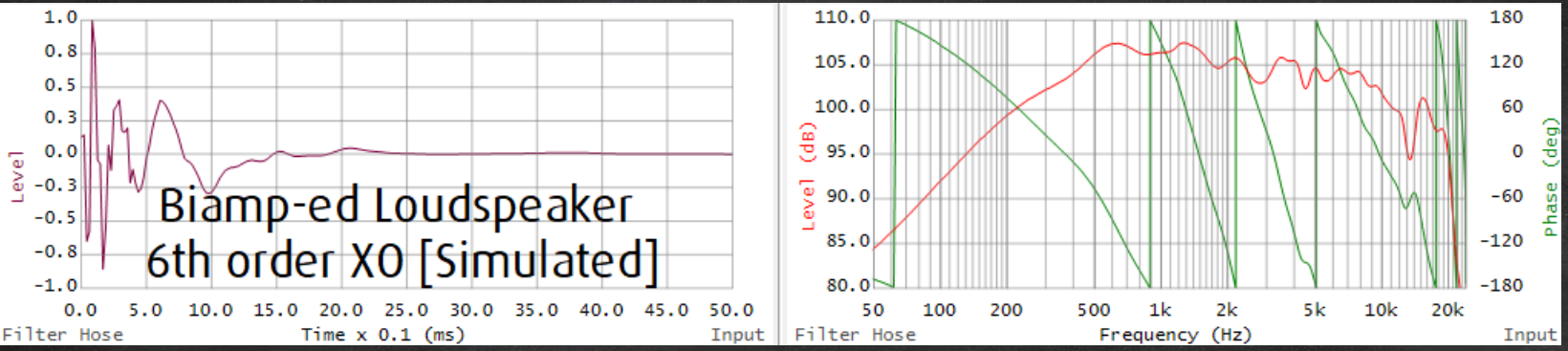
Vs

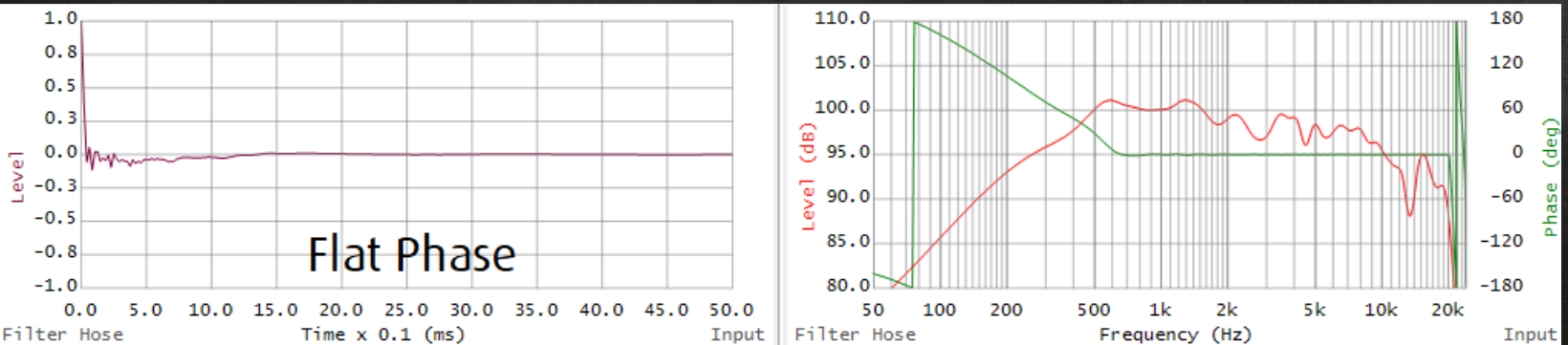
Bi-amp
(6th order active min phase crossover at same freq point, no change on the magnitude)

Vs

Original Response + FIR
(No change on the magnitude, flat phase)


Original Measurement
2nd order Passive XO
Level
Time x 0.1 (ms)
Filter Hose
Input
Level (dB)
Phase (deg)
Frequency (Hz)


Biamp-ed Loudspeaker
6th order XO [Simulated]
Level
Time x 0.1 (ms)
Filter Hose
Input
Level (dB)
Phase (deg)
Frequency (Hz)


Flat Phase
Level
Time x 0.1 (ms)
Filter Hose
Input
Level (dB)
Phase (deg)
Frequency (Hz)

F.A.Q: If less phase drop or flat phase is preferred, when do you use higher order (> 4th order) crossover?

We do not suggest that flatter phase is preferred or better sounding.

In engineering, there is no free lunch. There are always pros/cons to a method. Low order (< 4th order) crossover can reduce the phase drop and reduce the processing delay of an FIR filter to further flatten the response. High order (>= 4th order) crossover can result in lower distortion, higher output capability and cleaner sound. Certainly, we do not want low order crossover breaking the transducer in a long-term high-power use, do we?

What's the application of the loudspeaker?

What's the goal of the filter?

Is the change (phase resp change) meaningful to the project's objectives?

We can reduce our appetite of having flat line to the eyes, because the ears don't 'see' that. It's better to focus on the bigger picture first.

Audio lab

THANK YOU!

Contact info:

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Song for auralization: A Thousand Roads, composed by Ulf Anneken