

A Loudspeaker Management System with FIR / IIR Filtering

Rainer Thaden¹, Swen Müller², Gottfried Behler³
Anselm Goertz¹, Michael Makarski¹, Jochen Kleber⁴

1 Four Audio GmbH & Co. KG, Germany

2 Divisão de Acústica, INMETRO, Xerém, Brazil

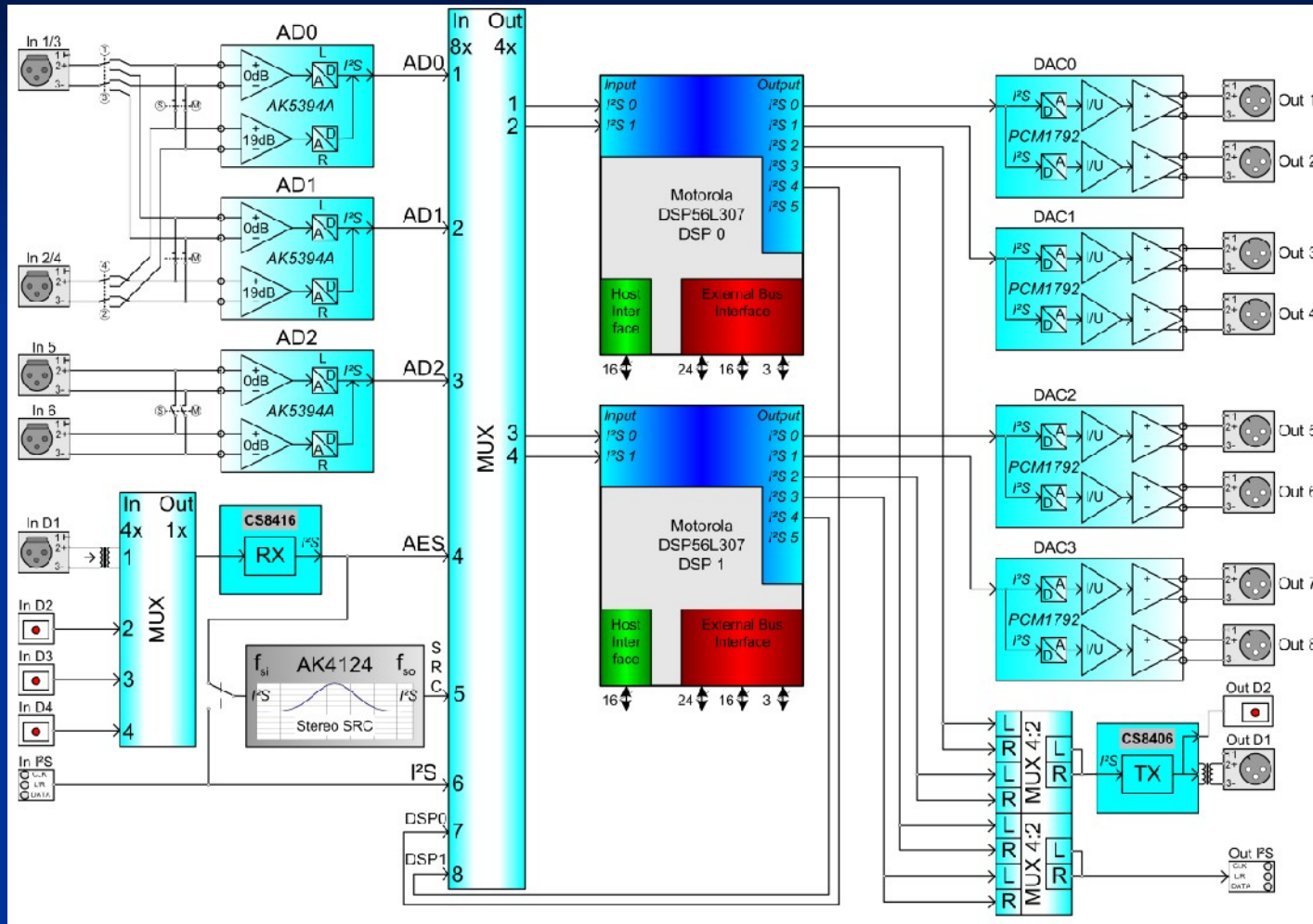
3 Institute of Technical Acoustics, RWTH Aachen University

4 Camco GmbH, Germany

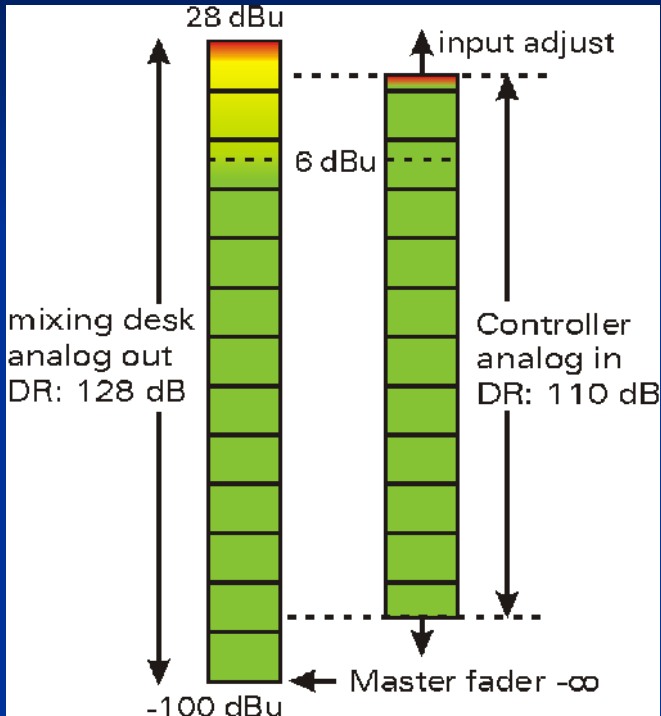
Motivation

- Reproduce music signal as faithfully as possible
 - Time and frequency domain
 - Noise / THD
- Protect speakers
 - Mechanical damage
 - Overheating

Architecture

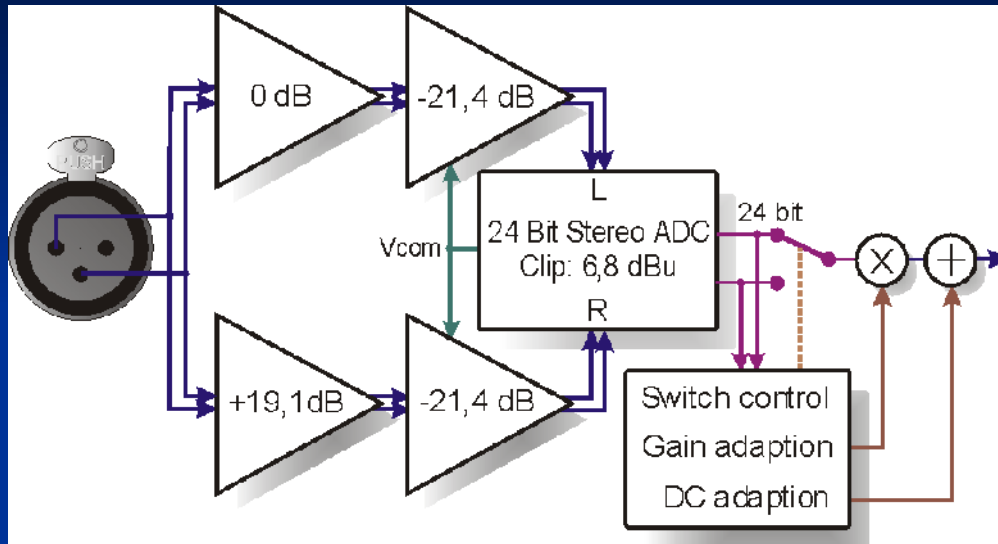


Dual Range AD Conversion



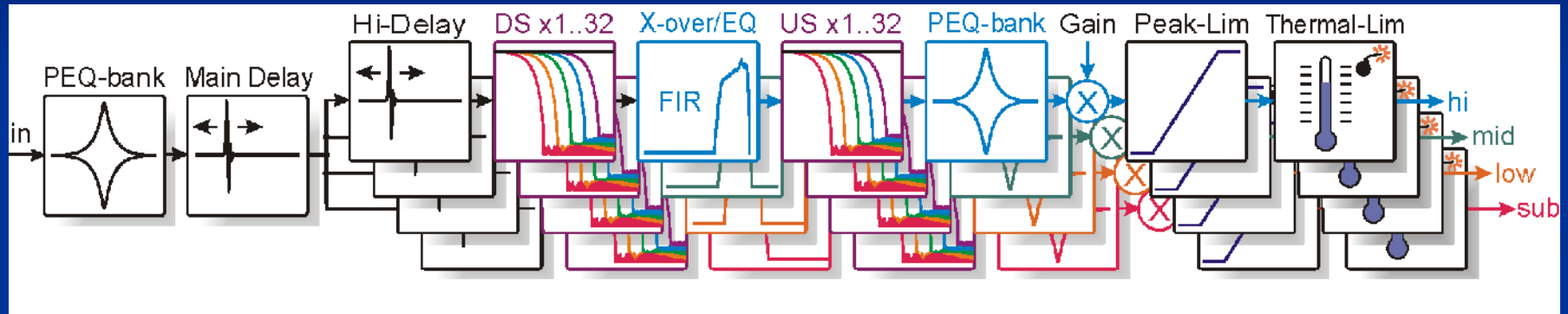
- DR of LMS smaller than mixing desk
- Decision: headroom for limiter or noise
- Switches or dials to adjust DR boundaries

Dual Range AD Conversion (2)

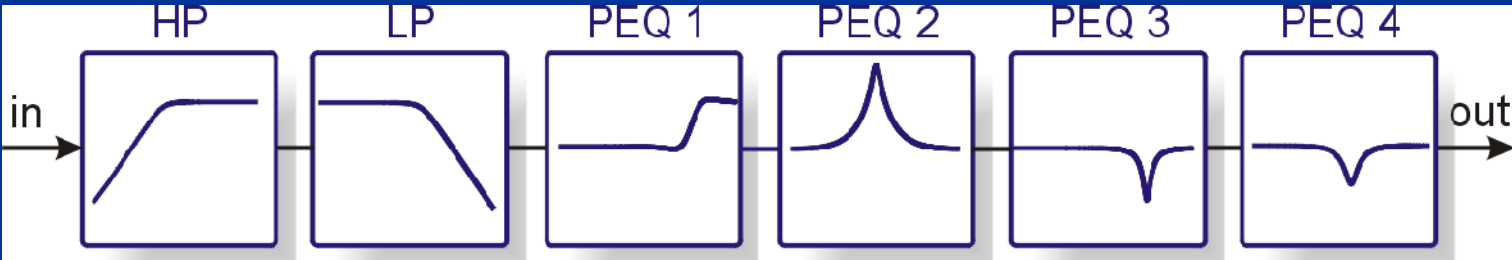
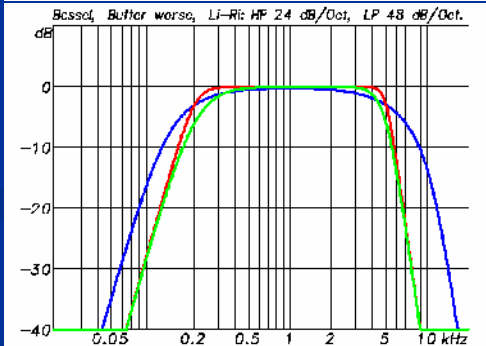
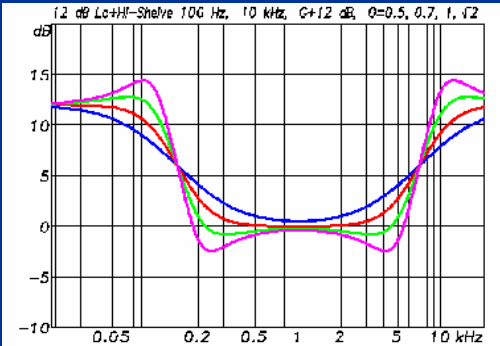
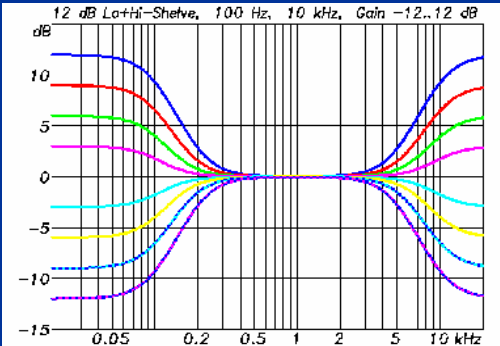
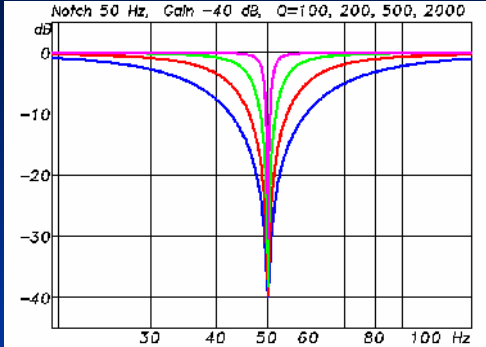
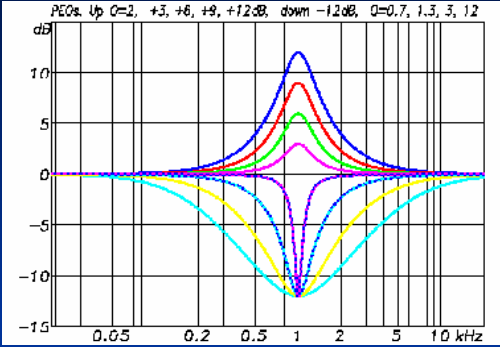
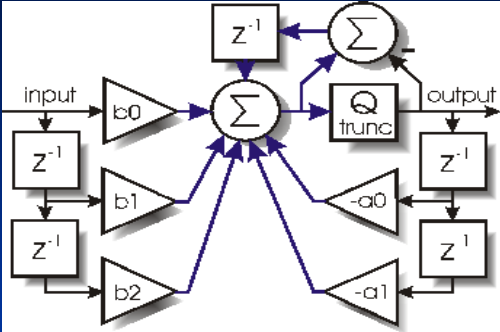


- Use stereo ADC in mono config.
- Two different gains
- Extend dynamic range by 19.1 dB

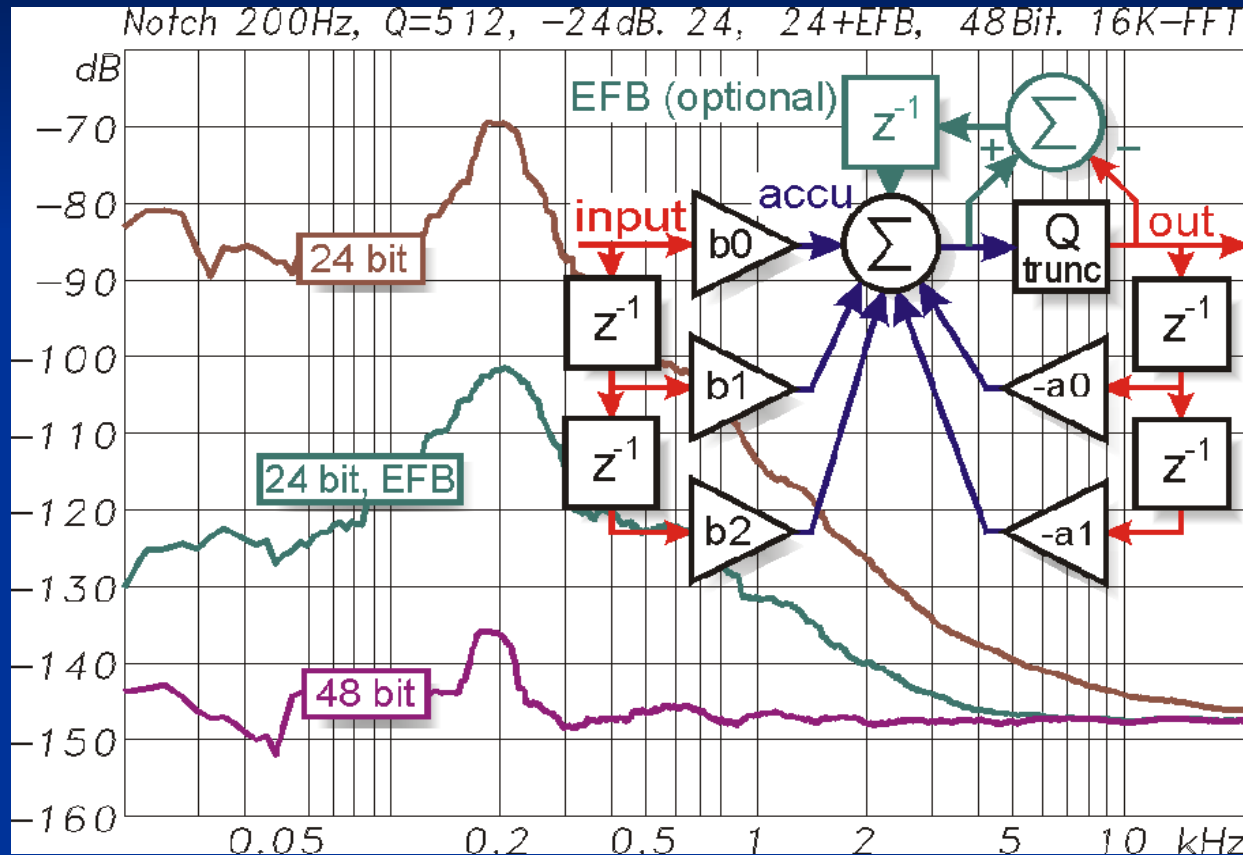
Signal Processing



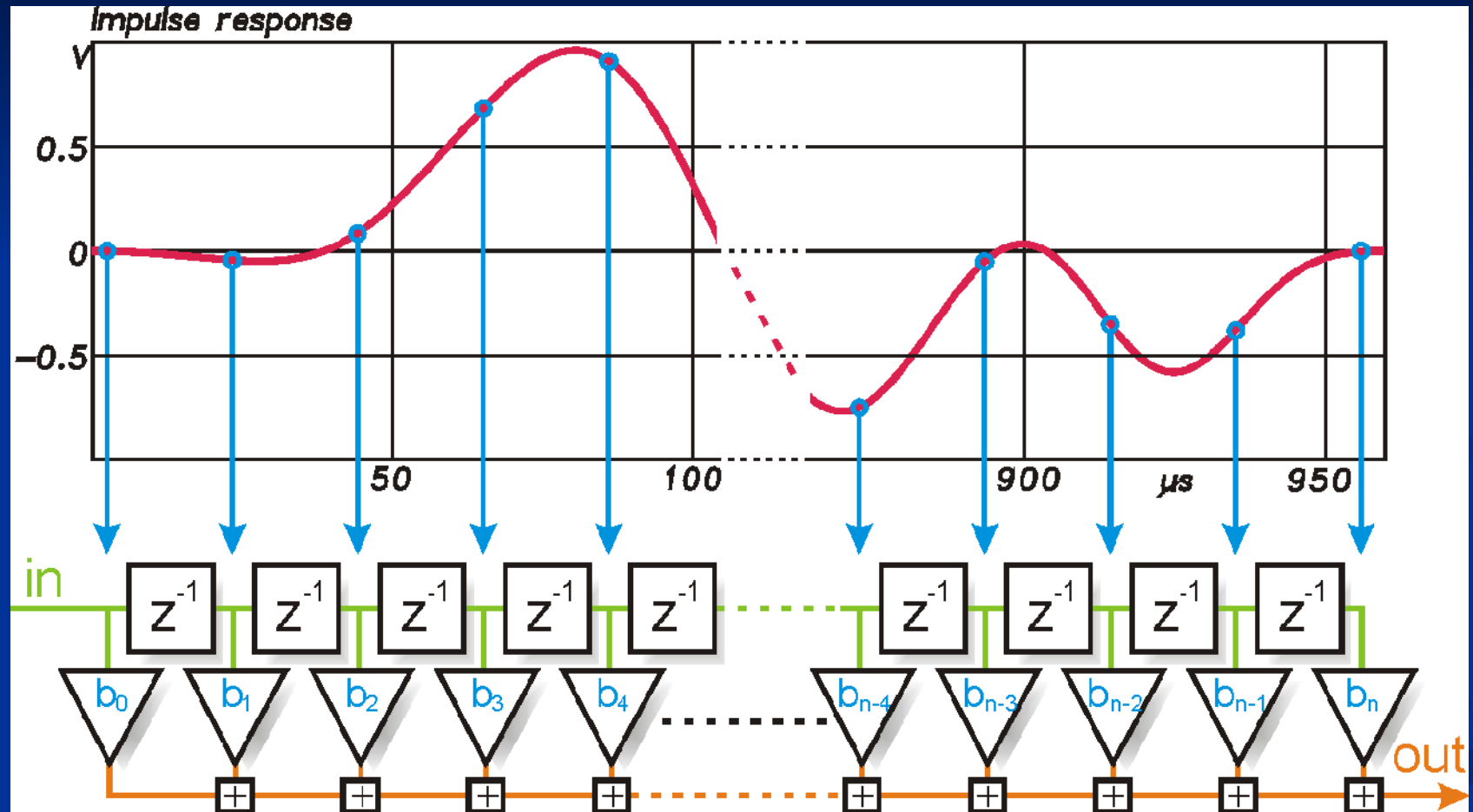
IIR Filtering



IIR Filtering (2)

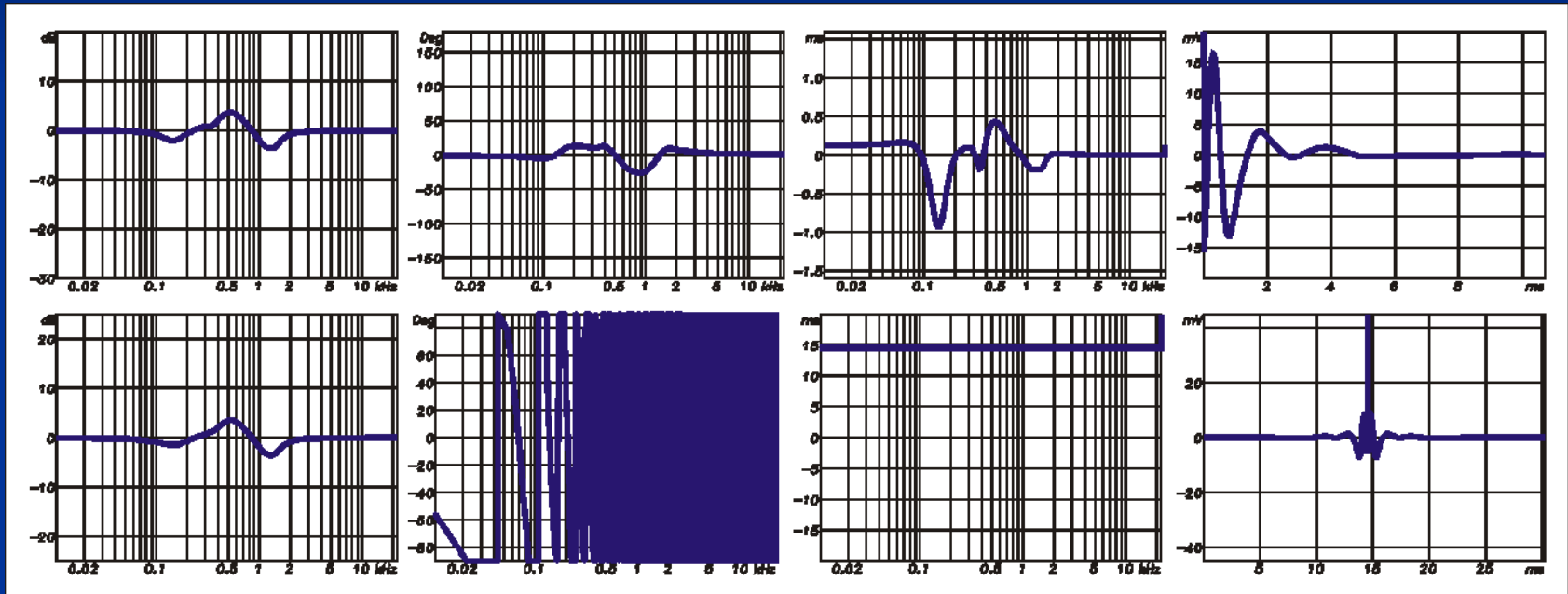


FIR Filtering



FIR Filters

■ Minimum phase vs. linear phase



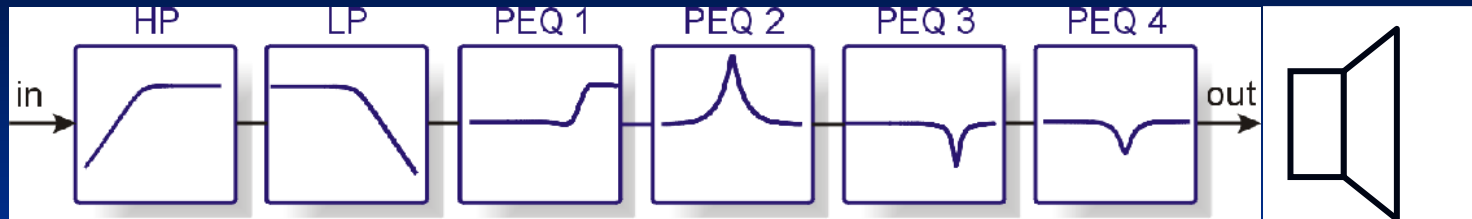
Freq. Resp

Phase

Group Delay

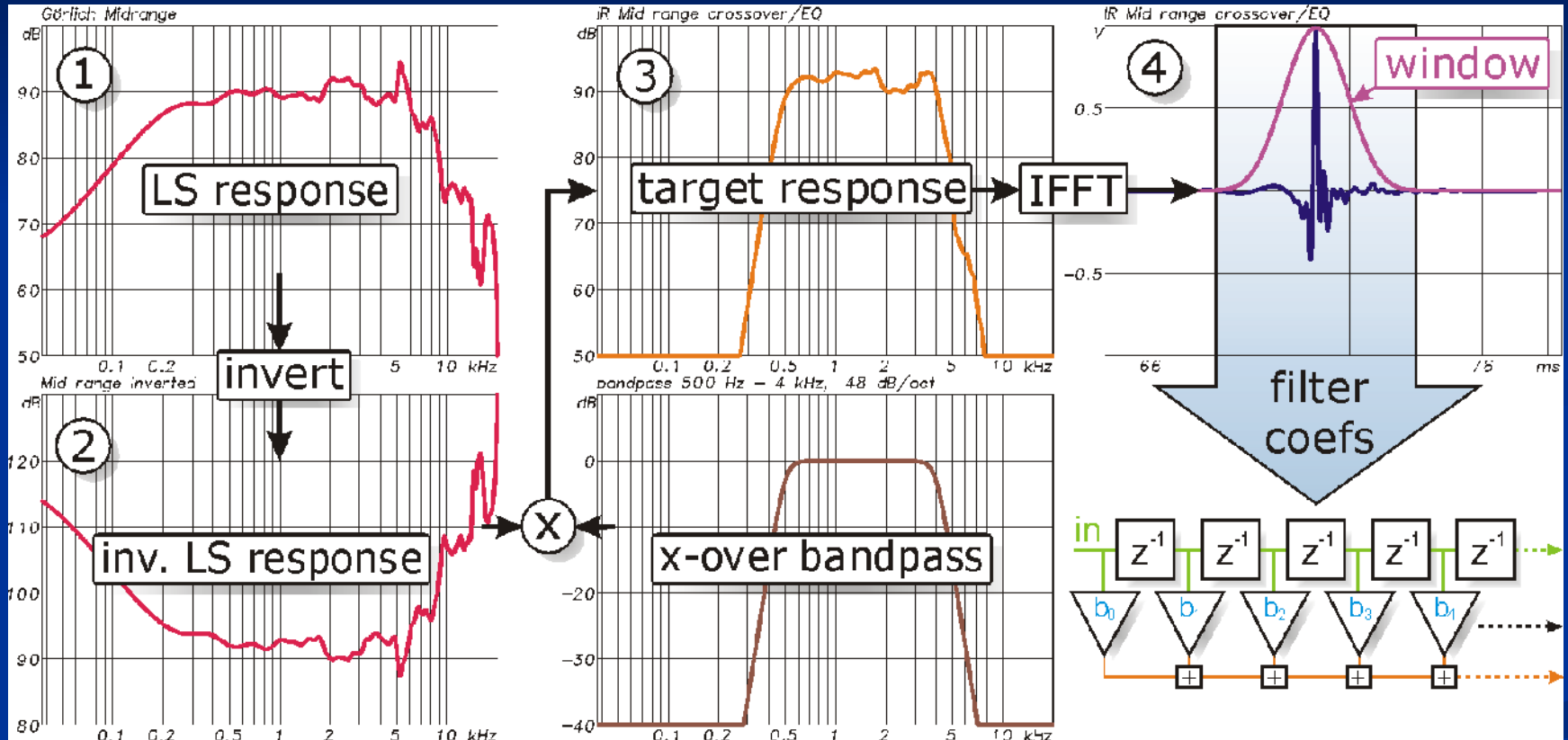
Imp. Resp

Equalizing the Loudspeaker

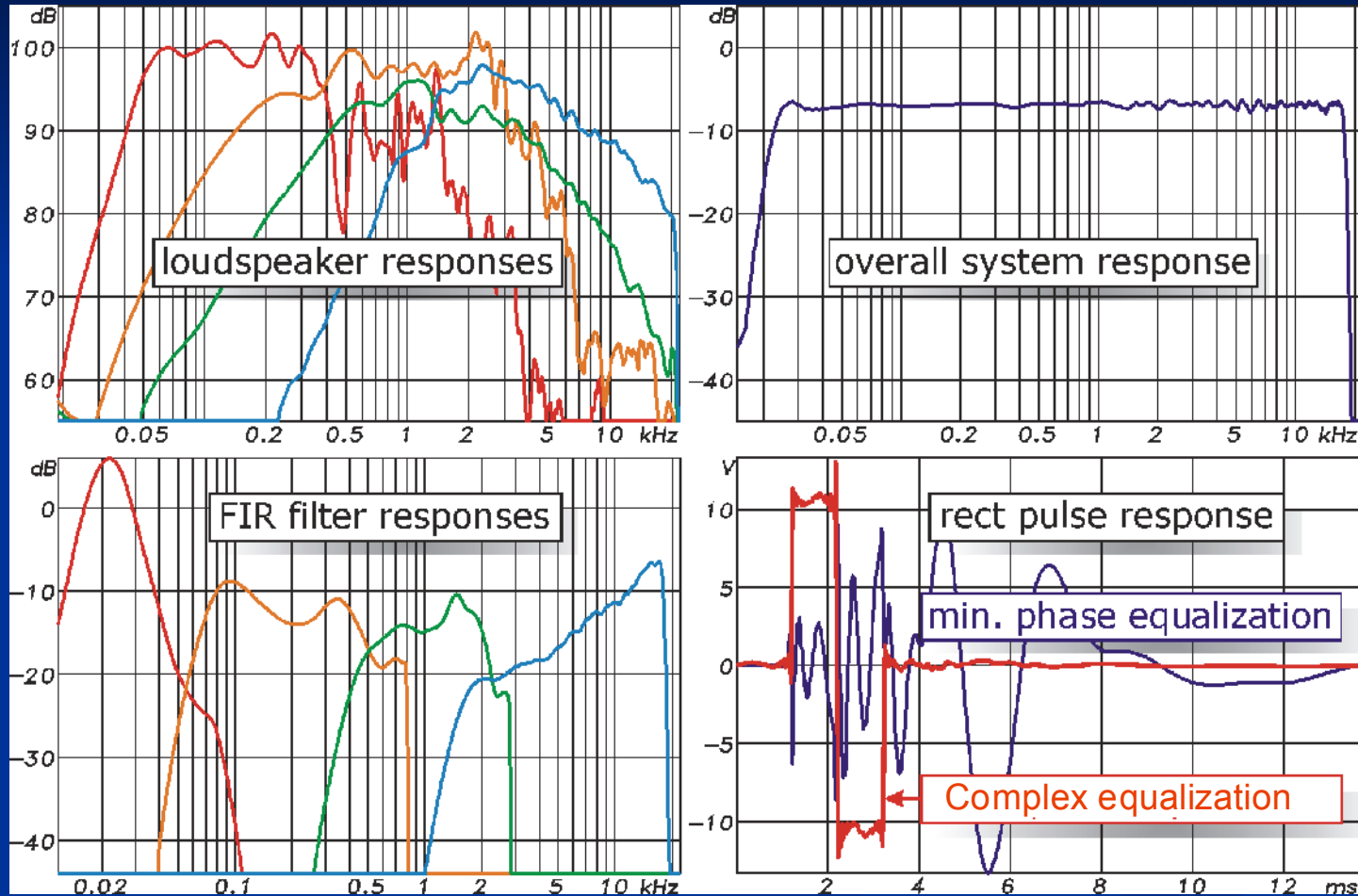


- IIR Filters
 - Filters introduce phase distortion as well as LS
- Linear phase FIR filters
 - Filters don't introduce phase dist. but LS does
- Complex equalizing
 - Inverse of LS impulse response is used as filter thus (ideally) no phase distortion

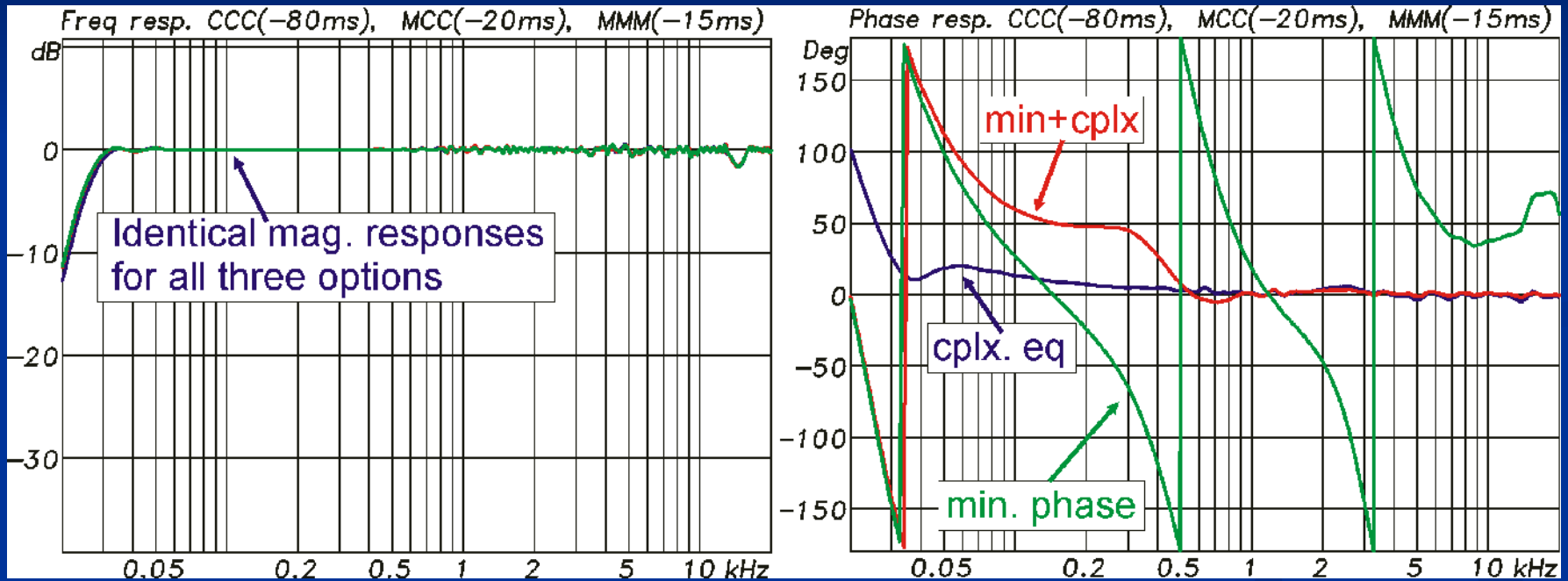
FIR Filtering (2)



FIR Filtering (3)



Phase Responses (Overall System)

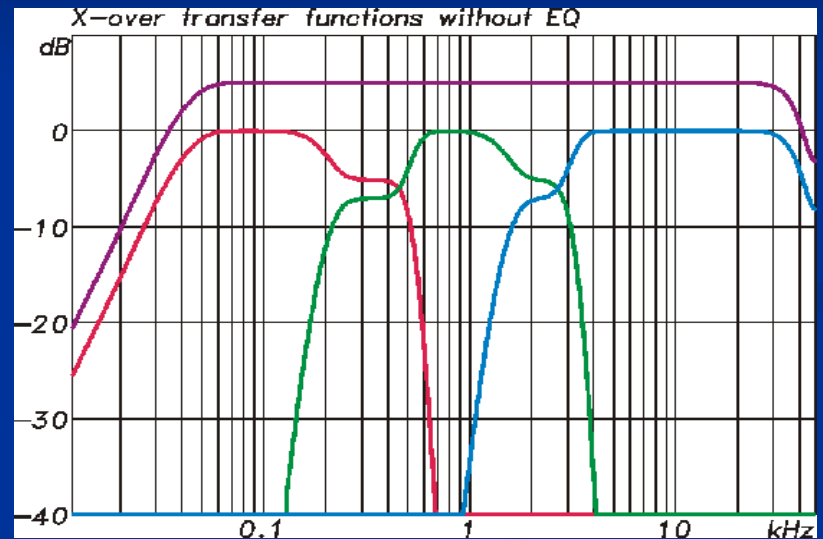
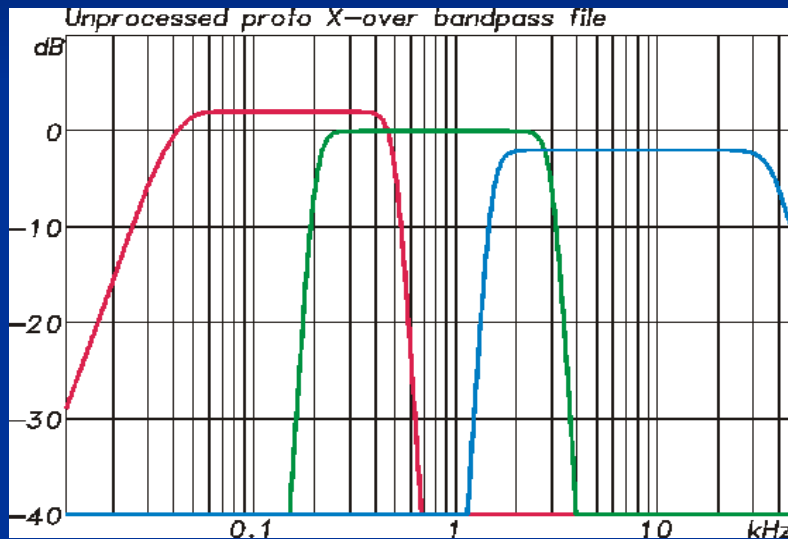


Multirate Processing

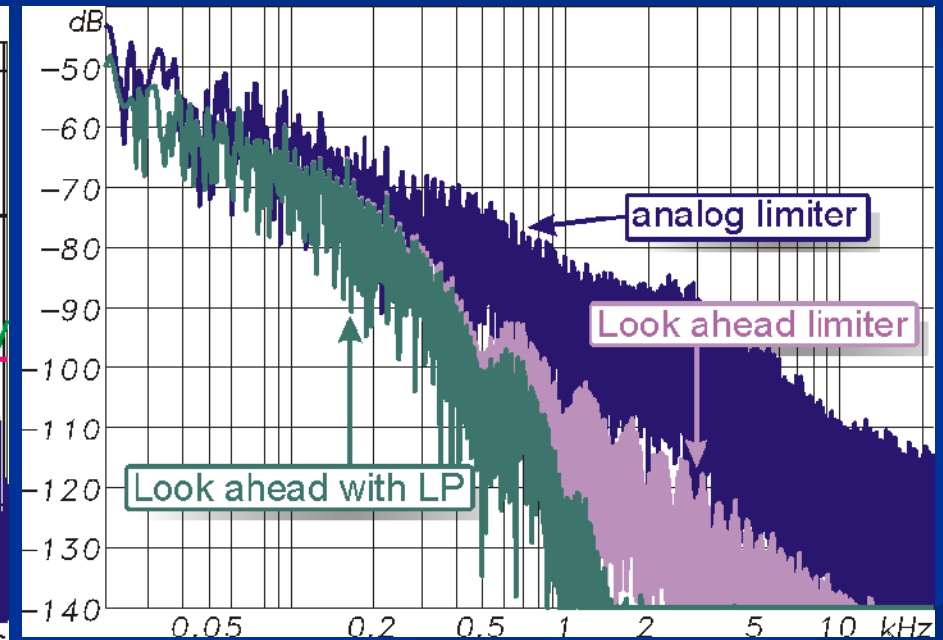
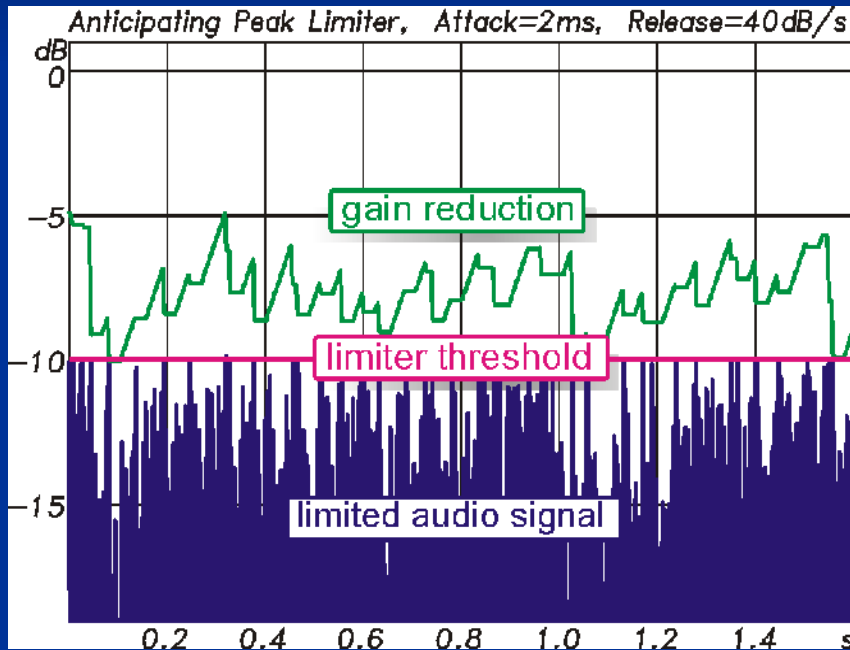
- FIR filtering at low frequencies requires many many many coefficients
 - $48000 \text{ Hz} / 512 \text{ taps} = 93,75 \text{ Hz resolution}$
 - High computational load for higher resolution
 - Use downsampling:
 - $48000 \text{ Hz} / 16 / 512 = 5,86 \text{ Hz}$

Advanced FIR Filtering

- Overlapping bands, e.g. to influence directivity

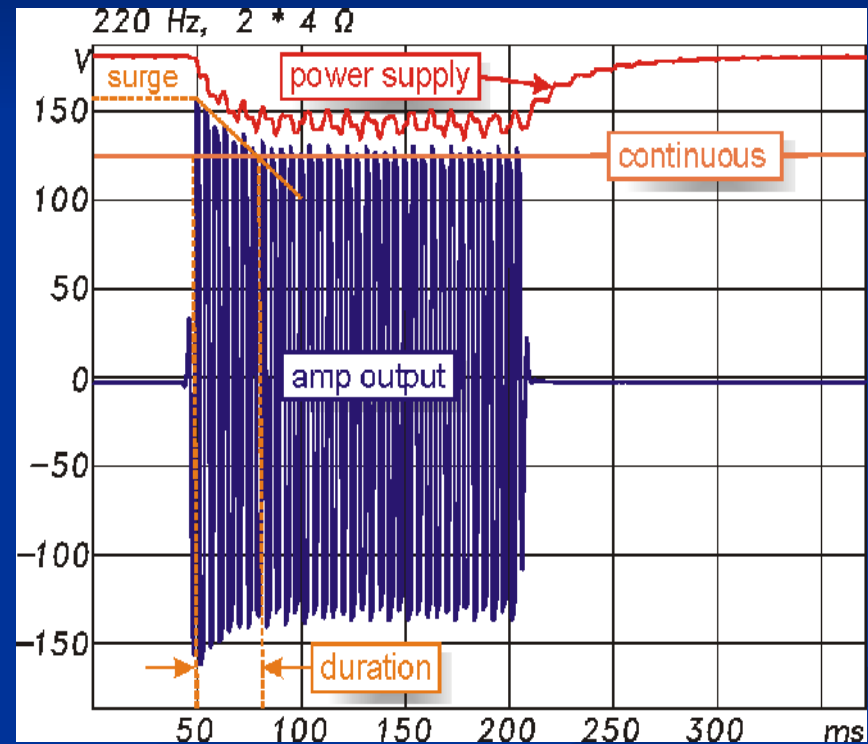


Gain Reduction Spectrum



Controlled Overshoot

- Simulate capacitor surging in power supply
 - Preserves the „Kick“



Summary

- Dual Range AD Conversion extends dynamic range
- Combined IIR and FIR filters

Summary (2)

- FIR filters
 - Allow using steep slopes for crossover networks without additional phase distortion
 - Using complex equalizing allows to equalize amplitude and phase
 - Beneficial for advanced concepts in crossover design
 - Multirate concept allows high frequency resolution at low frequencies

Summary (3)

- Dual limiter concept allows separate protection mechanisms against mechanical damage and overheating
- Toolbox for conventional and unconventional crossover design if you know what you are doing

Really the End

Thank You

CAMCO

