

# Realization of a Dynamic Equalizer for Audio Signals using Linear Phase IIR Digital Filters

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## Introduction

- This presentation is about the properties and the application of a novel digital linear phase dynamic equalizer:
  - the fundamental operating mode of the dynamic equalizer will be shown
  - listening examples will be given
  - a new approach for linear phase filtering with IIR filters will be presented

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## Control characteristic curve II

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## Dynamic Equalizer

- What is a dynamic equalizer?
  - a dynamic equalizer is a equalizer whose gain is under control of an internally generated control signal
  - the equalizer responds to the detected envelope of the program material in a certain frequency band
- Motivation for a dynamic equalizer
  - better control over dynamic signals and ‚critical‘ material
  - frequency bands can be controlled independently of each other
  - allows the use as a more flexible multiband compressor

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## Control characteristic curve III

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## Block diagram of the Dynamic EQ

- 4 dynamic bands are available
- each band can have either parametric, lo- or high shelf characteristic
- the user can choose between static gain, dynamic gain or a mixture of both per band
- the dynamic part is controlled by the parameters ‚threshold‘, ‚attack‘ and ‚release‘
- bandpass filter ‚frequency‘ and ‚Q‘ can be ‚linked‘ with the equalizer

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## Filtering with digital IIR filter

- a digital IIR filter can be described by the transfer function:
 
$$H(z) = \frac{a_0 + a_1 \cdot z^{-1} + a_2 \cdot z^{-2}}{1 + b_1 \cdot z^{-1} + b_2 \cdot z^{-2}}$$
- to achieve a certain filter curve, the coefficients have to be defined accordingly
- to keep track of the dynamic changes, the coefficients have to be continuously recalculated

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## Area of application

- Mastering:
  - increase of loudness through 'compressing' of frequency bands
  - accommodation of the spectral balance
  - correction of frequency peaks
  - bringing out hidden instruments in a mix
- Restoration:
  - elimination of background noise
  - dynamic boost or cut of important or annoying spectral components
- Deessing:
  - removal of annoying hisses in spoken word or vocal recordings
- Creative sound design

## Linear phase IIR filter

- Linear Phase IIR (Infinite Impulse Response) filter allow the generation of a symmetric impulse response with IIR structures
- Advantages:
  - it is possible to use nearly the same structures and coefficients as in the nonlinear phase case
  - IIR filters demand much less processing power

## Linear phase Dynamic Eq

- Motivation:
  - by linear phase filtering the coloring of sound caused by phase effects can be prevented
  - especially interesting for mastering purposes since the original sound character of the processed material can be maintained

## Linear phase IIR filter principle

- 1.) a signal is sent through an IIR filter      2.) the signal gets reversed in time



- 3.) the time reversed signal is sent through the same IIR filter again      4.) the signal gets reversed in time again

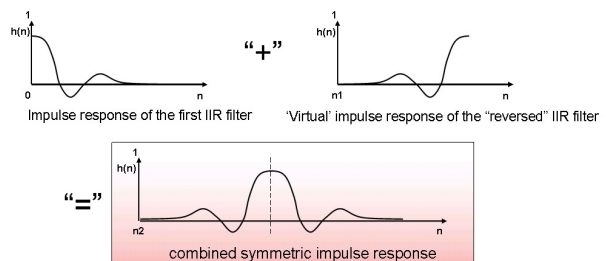


The result is a linear phase filtered signal with a doubled amplitude transfer function. The phase shifts cancel out each other through the double filtering.

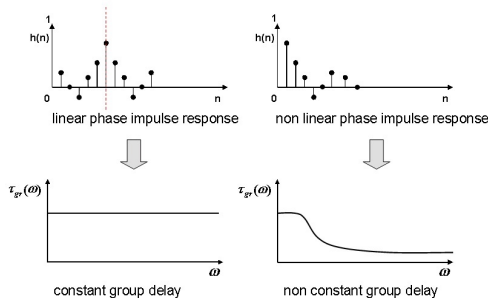
## How can linear phase filtering be achieved?

- a necessary requirement for a system to be called 'linear phase' is the existence of a symmetrical impulse response
- the impulse response can either be axially or point symmetric
- a common method to achieve symmetric impulse responses is the use of FIR (Finite Impulse Response) filters:

## Linear phase IIR filter impulse responses



## FIR-Filters of equal amplitude response



## Conclusion

- A novel approach of a dynamic equalizer that utilizes Linear Phase IIR filters has been presented
- This approach proved being superior compared to filtering with conventional FIR filters due to the requirements of the dynamic filtering (fast changing filter impulse response)
- The dynamic filtering now can be performed either in a non linear phase or linear phase way