Active Noise Control of Speech in Headphones

using Linear Prediction

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> Acoustics and Audio Technology - Fall 2016 Department of Electronic Systems Aalborg University Denmark





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What is Active No Control (ANC)

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Methods

Feedforward FXLM

Linear Predict

Combined sys

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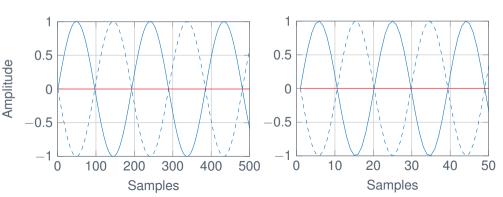
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► The basic theory of ANC

- ▶ 250 Hz
- ▶ 2500 Hz

- Original signal
- - Counterphase signal
- Error





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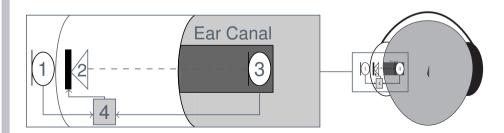
Acoustics and Audio Technology Dept. of Electronic Systems Aalborg University ► Feedforward system

► 1: Reference microphone

► 2: Headphone loudspeaker

3: Error mirophone

► 4: Digital signal Processor (DSP)





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► Feedforward problem

- Sampling and reconstruction delay.
 - ► Anti Aliasing filter
 - Reconstructions filter
- ► The measured delay of a Sigma Delta converter TLV320AIC3204

f _s [kHz]	48	96	192
Delay [μ s]	900	450	225
Delay [samples]	43	43	43

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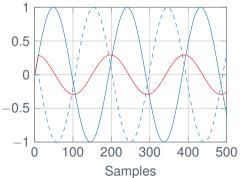
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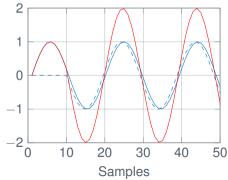
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Acoustics and Audio Technology Dept. of Electronic Systems Aalborg University ► Counter phase signal delayed 10 samples

- ▶ 250 Hz
- ▶ 2500 Hz

- Original signal
- - Counterphase signal
- Error







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Problem of ANC

Simulations Results

▶ Signal Characteristics

- ▶ Periodic Signals
 - Periodic

 - ► Strict Sense Stationary (SSS)
- ► Speech Signals
 - Quasiperiodic
 - ► Can be assumed Wide Sense Stationary for 20 ms 30 ms
- Periodic noise is easy to cancel
- Speech noise is difficult to cancel

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▶ How well does the consumer headphones attenuate?

► Denon AH-GC20

2.200 kr (2016)

Bose QC25

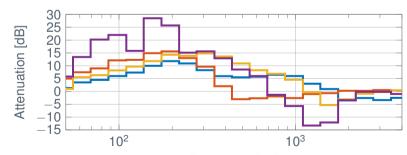
2.799 kr (2016)

► Bose QC15

2.696 kr (2011)

► BeoPlay H8

3.495 kr (2016)



Frequency [Hz]



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Present consumer

headphones

Simulations Results

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Combining a feedforward Filtered-x Least Mean Square (FXLMS) algorithm with Linear prediction (LP) scheme to compensate for delay.



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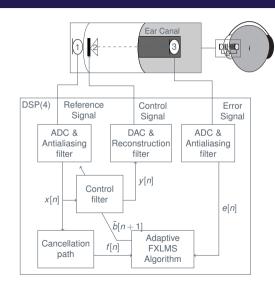
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- ► Control filter
 - ► Transfer function from (1) to (2)
 - Adaptive
- Cancelation path
 - ► Transfer function from (2) to (3)
 - ► Linear Time Invariant
- ► Adaptive FXLMS Algorithm
 - ► Transfer function from (2) to (3)
 - ▶ Linear Time Invariant





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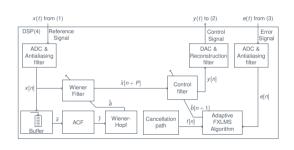
Discussion

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Acoustics and Audio Technology Dept. of Electronic Systems Aalborg University ▶ Control filter

- ► Transfer function from (1) to (2)
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- ▶ Adaptive FXLMS Algorithm
 - ► Transfer function from (2) to (3)
 - ▶ Linear Time Invariant





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Questions?

