# 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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Introduction

What is Active No Control (ANC)

Problem of Al

Present con:

headphones

Methods

Feedforward FXLM

Linear Predict

Combined sys

Simulations Results

Computation

Conclus

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12

Introduction

What is Active Noise Control (ANC)

Problem of ANC

Present consumer headphones

Methods

Feedforward FXLMS

Linear Prediction

Combined system

Simulations Results

Discussion

Computation

Conclusion

Listen



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Control (ANC)

Problem of ANC

Present consu

# Methods

Feedforward FXLMS

Linear Predicti

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Computatio

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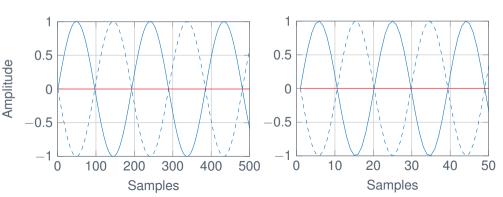
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► The basic theory of ANC

- ▶ 250 Hz
- ▶ 2500 Hz

- Original signal
- - Counterphase signal
- Error





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Problem of AN

Present cons

# Methods

Feedforward FXLMS

Linear Predicti

Simulations Results

### Simulations Result

Discussion

Computation

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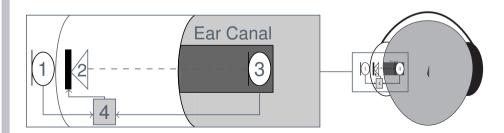
Acoustics and Audio Technology Dept. of Electronic Systems Aalborg University ► Feedforward system

► 1: Reference microphone

► 2: Headphone loudspeaker

3: Error mirophone

► 4: Digital signal Processor (DSP)





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Linear Predicti

Combined system

# Simulations Results

Computation

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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 <sub>s</sub> [kHz]	48	96	192
Delay [ $\mu$ s]	900	450	225
Delay [samples]	43	43	43

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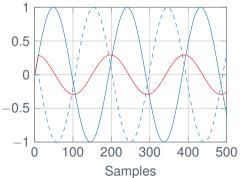
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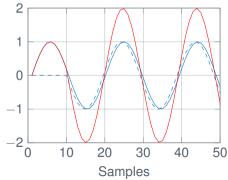
Conclusio

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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Computation

Conclusion

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▶ How well does the consumer headphones attenuate?

► Denon AH-GC20

2.200 kr (2016)

Bose QC25

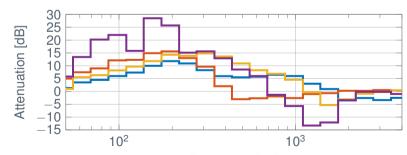
2.799 kr (2016)

► 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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Present consum

# Methods

### Feedforward EXLMS

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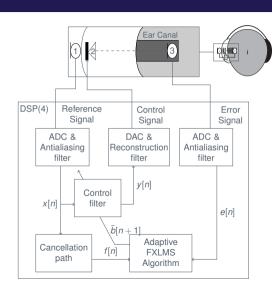
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What is Active Noise

Problem of AN

Present consum

# Methods

Feedforward FXLN

# Linear Prediction

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Simulations Results

Discussion

Computation

Conclu

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## Introductio

What is Active Nois

Problem of Al

Present consum

# Methods

Feedforward FXLMS

Linear Prediction

Combined system

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Simulations Results

Computation

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What is Active Nois

Problem of All

Present consum

headphones

### Methods

Feedforward FXLN

Linear Predicti

Combined evet

Simulations Results

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Computation

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Problem of ANC

Present consum

# Methods

Feedforward FXLMS

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Simulations Result

# Discussion

Conclusion

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Present consum headphones

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Mikkel for president!



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