

# Active Noise Control of Speech in Headphones

using Linear Prediction

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Kasper Kiis Jensen, Maxime Démurger  
Oliver Palmhøj Jokumsen, Christian Claumarch  
Mikkel Krogh Simonsen  
16gr761@es.aau.dk

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



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# Agenda

Active Noise Control of  
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Group 761

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Problem of ANC  
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## What is ANC

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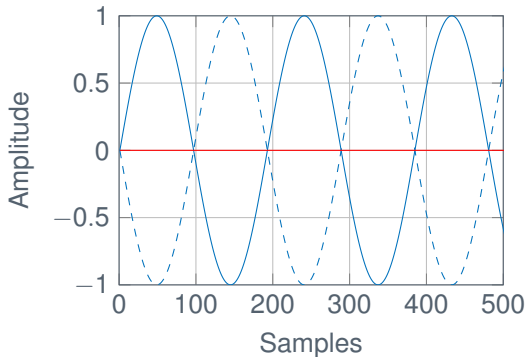
Conclusion

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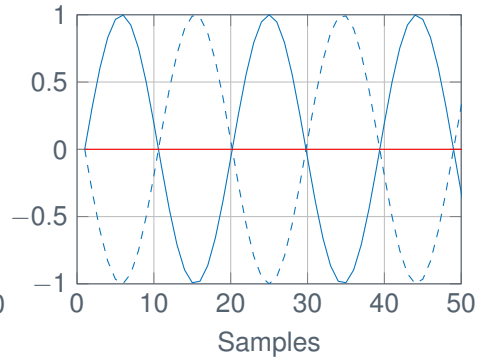
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### ► The basic theory of ANC

- 250 Hz
- 2500 Hz



- Original signal
- - Counterphase signal
- Error



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# Introduction

## How does ANC work

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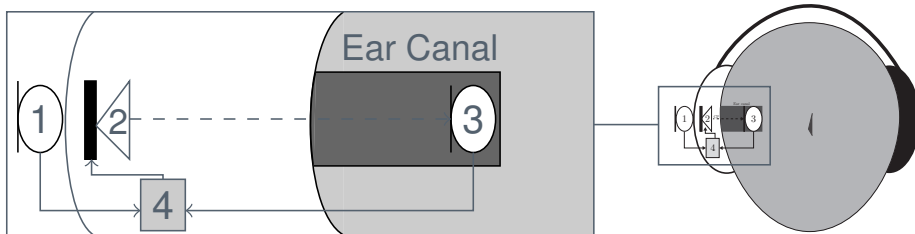
#### Conclusion

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### ► Feedforward system

- 1: Reference microphone
- 2: Headphone loudspeaker
- 3: Error microphone
- 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 [ $\mu$ s]	900	450	225
Delay [samples]	43	43	43

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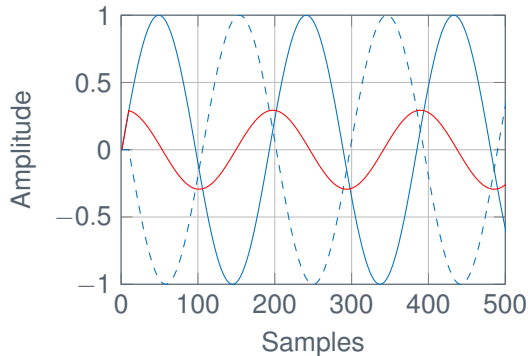
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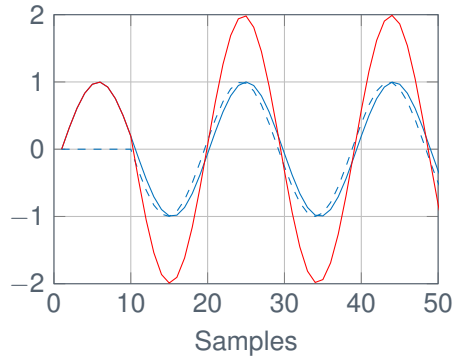
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- ▶ Counter phase signal delayed 10 samples

- ▶ 250 Hz
- ▶ 2500 Hz



- Original signal
- - Counterphase signal
- Error





# Introduction

## Speech vs Periodic Noise

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- ▶ 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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## Present consumer headphones

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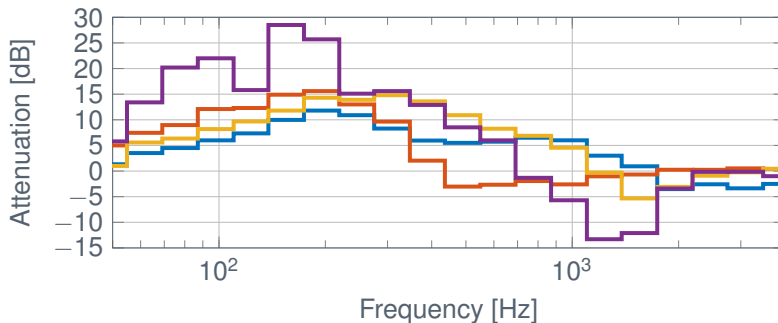
### Conclusion

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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)







# Introduction

A solution for the problem

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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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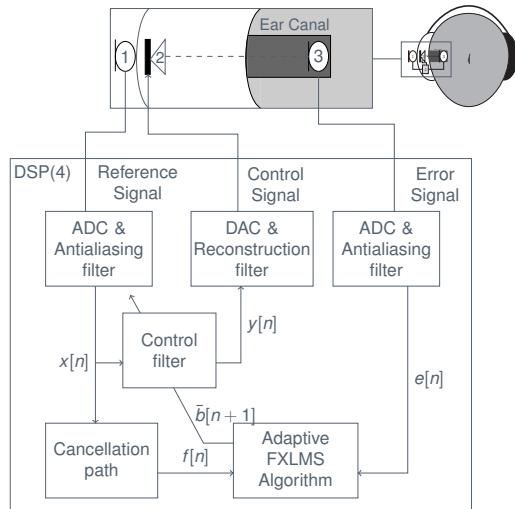
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## Linear Prediction

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## Combined system

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# Methods

## Optimal parameters

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Kiis for President!







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Mikkel for president!





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