

Active Noise Control of Speech in Headphones

using Linear Prediction

16. december 2016

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



AALBORG UNIVERSITY
DENMARK

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

Conclusion

Listen

Introduction

What is Active Noise Control (ANC)

Problem of ANC

Present consumer headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

Conclusion

Listen

Introduction

What is ANC

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

Conclusion

Listen

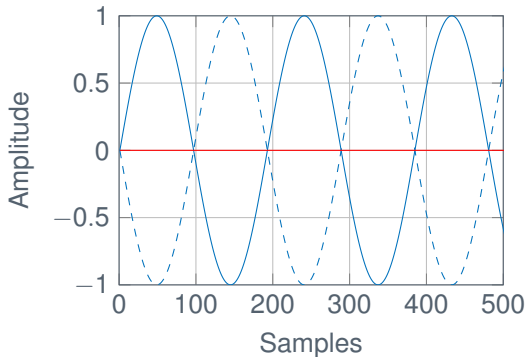
Acoustics and Audio
Technology
Dept. of Electronic Systems
Aalborg University
Denmark

2

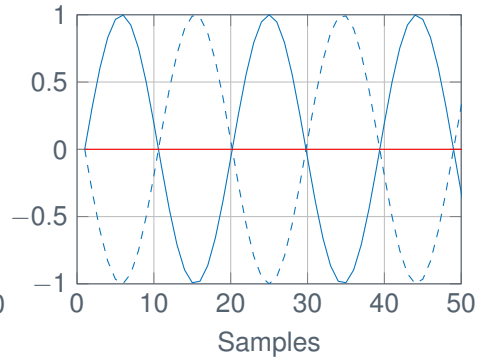
10

► The basic theory of ANC

- 250 Hz
- 2500 Hz



- Original signal
- - Counterphase signal
- Error



Introduction

How does ANC work

Active Noise Control of Speech in Headphones using Linear Prediction

Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

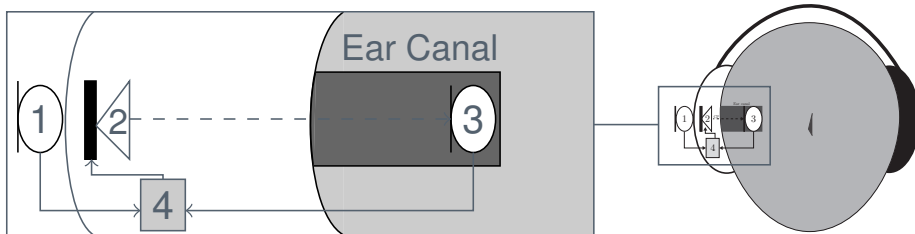
Conclusion

Listen

3

► Feedforward system

- 1: Reference microphone
- 2: Headphone loudspeaker
- 3: Error microphone
- 4: Digital signal Processor (DSP)



10

Introduction

Problem of ANC

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

Conclusion

Listen

4

- ▶ 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

Introduction

Problem of ANC

Active Noise Control of
Speech in
Headphones using
Linear Prediction

Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

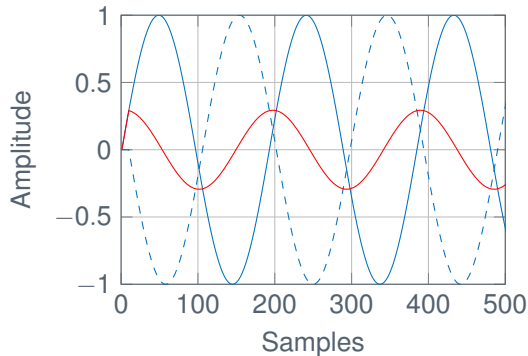
Conclusion

Listen

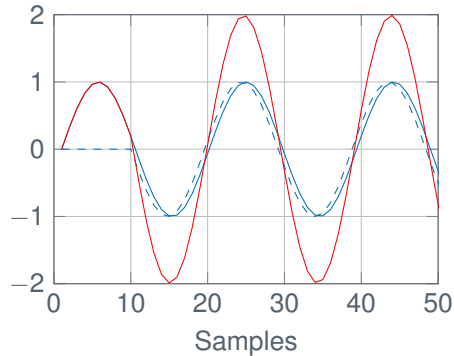
5

▶ Counter phase signal delayed 10 samples

- ▶ 250 Hz
- ▶ 2500 Hz



- Original signal
- - Counterphase signal
- Error



10

Introduction

Speech vs Periodic Noise

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

Conclusion

Listen

6

► 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

10

Introduction

Present consumer headphones

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction
What is Active Noise
Control (ANC)
Problem of ANC
Present consumer
headphones

Methods
Feedforward FXLMS
Linear Prediction

Results
Simulation

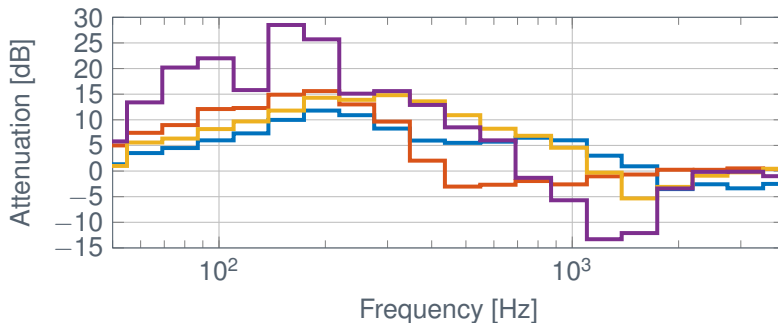
Discussion
Computation

Conclusion
Listen

Acoustics and Audio
Technology
Dept. of Electronic Systems
Aalborg University
Denmark

► 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

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

Results

Simulation

Discussion

Computation

Conclusion

Listen

Acoustics and Audio
Technology
Dept. of Electronic Systems
Aalborg University
Denmark

8

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

10



Methods

Feedforward FXLMS

Active Noise Control of
Speech in
Headphones using
Linear Prediction
Group 761

Introduction

What is Active Noise
Control (ANC)
Problem of ANC
Present consumer
headphones

Methods

Feedforward FXLMS
Linear Prediction

9

Results

Simulation

Discussion

Computation

Conclusion

Listen

Acoustics and Audio
Technology
Dept. of Electronic Systems
Aalborg University
Denmark

10



Methods

Linear Prediction

Active Noise Control of Speech in Headphones using Linear Prediction

Group 761

Introduction

What is Active Noise
Control (ANC)

Problem of ANC

Present consumer
headphones

Methods

Feedforward FXLMS

Linear Prediction

10

Results

Simulation

Discussion

Computation

Conclusion

Listen

10

Kiis for President!



AALBORG UNIVERSITY
DENMARK