

Active Noise Control of Speech in Headphones

using Linear Prediction

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Acoustics and Audio Technology - Fall 2016
Department of Electronic Systems
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What is Active Noise
Control (ANC)
Problem of ANC
Present consumer
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Methods

Feedforward FXLMS
Linear Prediction
Combined system

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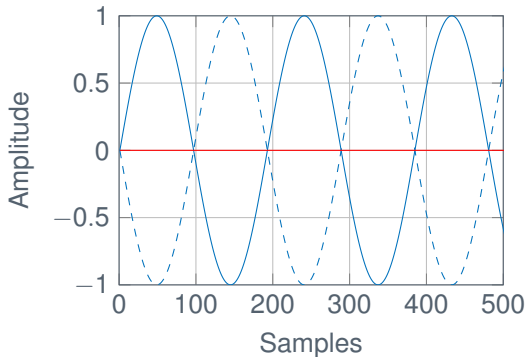
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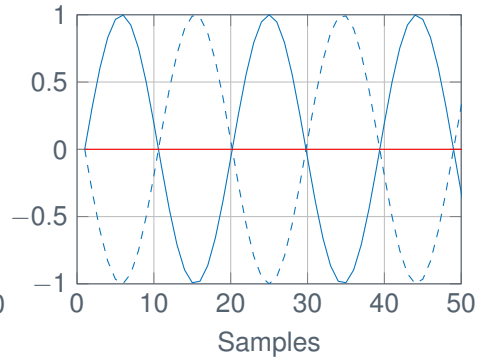
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► The basic theory of ANC

- 250 Hz
- 2500 Hz



- Original signal
- - Counterphase signal
- Error



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How does ANC work

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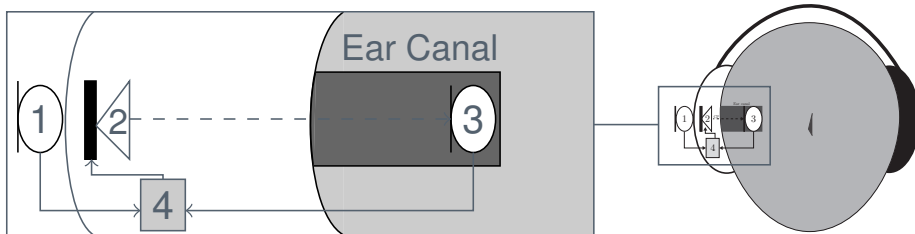
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► Feedforward system

- 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 [μ s]	900	450	225
Delay [samples]	43	43	43

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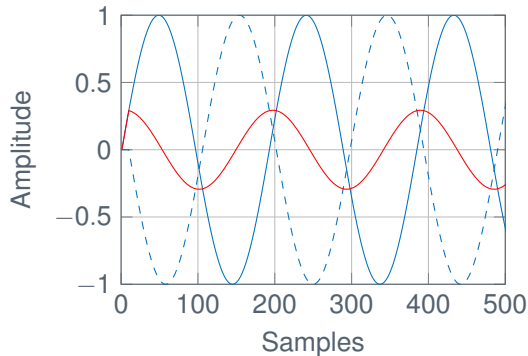
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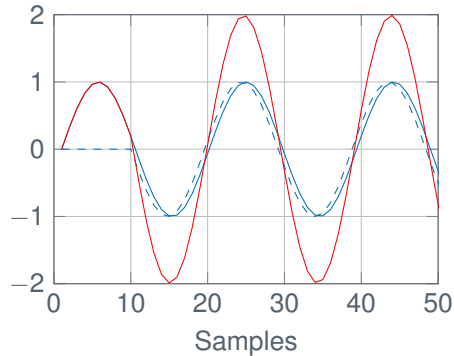
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- ▶ Counter phase signal delayed 10 samples

- ▶ 250 Hz
- ▶ 2500 Hz



- Original signal
- - Counterphase signal
- Error





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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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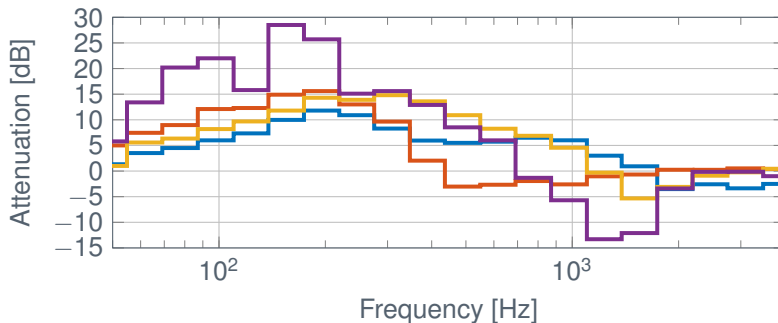
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► How well does the consumer headphones attenuate?

- 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)





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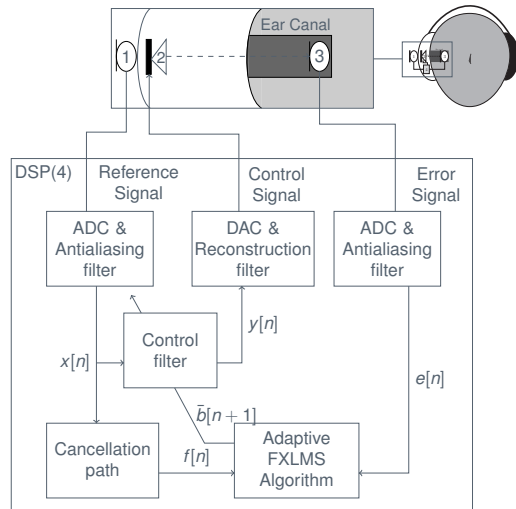
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- ▶ **Control filter**
 - ▶ Transfer function from (1) to (2)
 - ▶ Adaptive
- ▶ **Cancellation path**
 - ▶ Transfer function from (2) to (3)
 - ▶ Linear Time Invariant
- ▶ **Adaptive FXLMS Algorithm**
 - ▶ Transfer function from (2) to (3)
 - ▶ Linear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





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Linear Prediction

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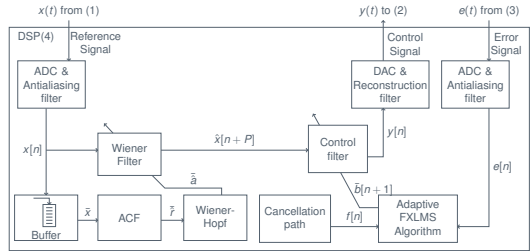
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- ▶ Control filter
 - ▶ Transfer function from (1) to (2)
 - ▶ Adaptive
- ▶ Cancellation path
 - ▶ Transfer function from (2) to (3)
 - ▶ Linear Time Invariant
- ▶ Adaptive FXLMS Algorithm
 - ▶ Transfer function from (2) to (3)
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Optimal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

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Questions?



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