# Active Noise Control of Speech in Headphones
## using Linear Prediction

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Acoustics and Audio Technology - Fall 2016
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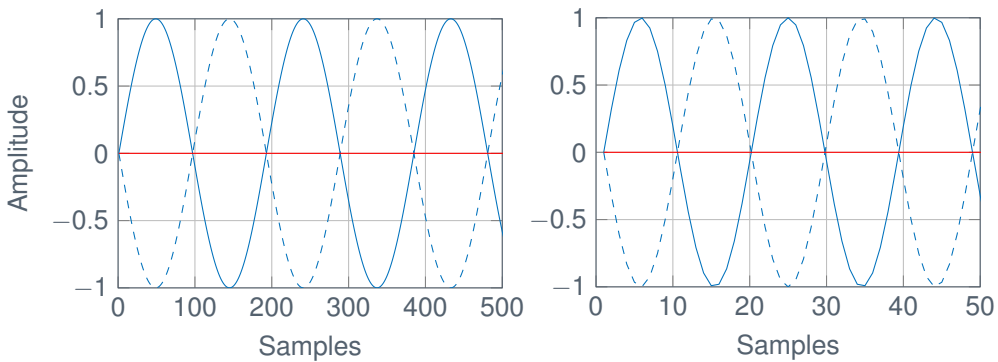
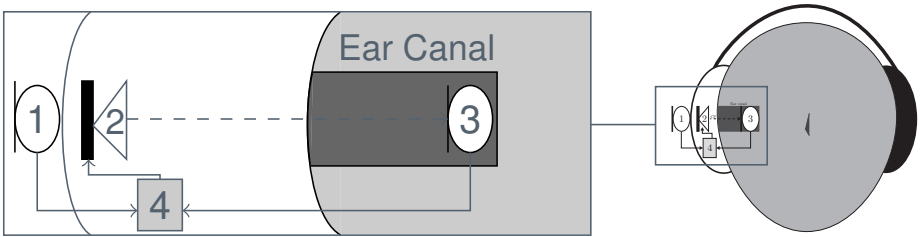
# Agenda

- The basic theory of ANC
  - 250 Hz
  - 2500 Hz



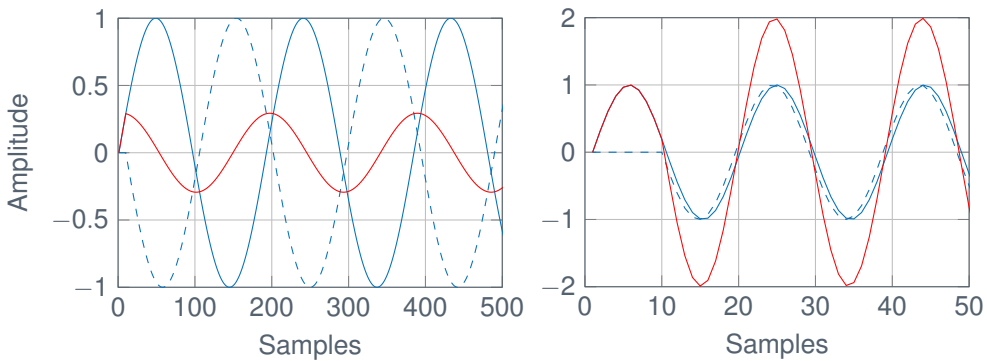
- Feedforward system
  - 1: Reference microphone
  - 2: Headphone loudspeaker
  - 3: Error mirophone
  - 4: Digital signal Processor (DSP)



- Feedforward problem
- Sampling and reconstruction delay.
  - Anti Aliasing filter
  - Reconstructions filter
- The measured delay of a Sigma Delta converter TLV320AIC3204
- Spacing between microphones
  - Min: 75.5 $m$m
  - Max: 302 $m$m

| $f_s$ [$k$Hz] | 48 | 96 | 192 |
|---|---|---|---|
| Delay [$\mu$s] | 900 | 450 | 225 |
| Delay [samples] | 43 | 43 | 43 |

- Counter phase signal delayed 10 samples
  - 250 Hz
  - 2500 Hz



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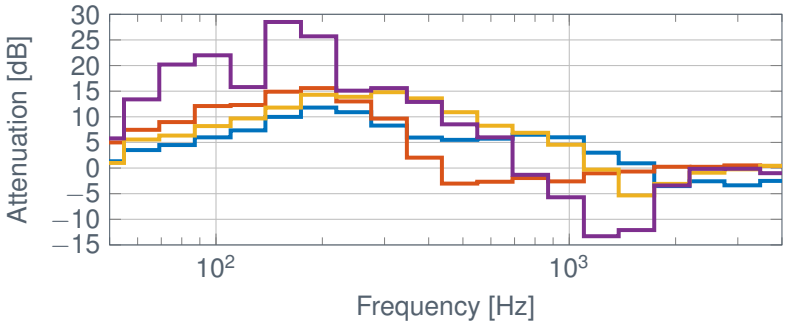
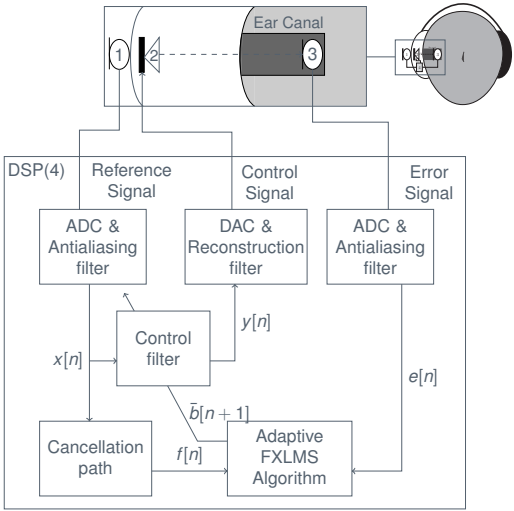
- Signal Characteristics
  - Periodic Signals
    - Periodic
    - Strict Sense Stationary (SSS)
  - Speech Signals
    - Quasiperiodic
    - Can be assumed Wide Sense Stationary for 20 $ms$ – 30 $ms$
- Periodic noise is easy to cancel
- Speech noise is difficult to cancel

- 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)



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

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



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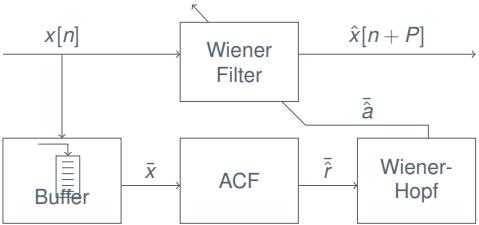
- Auto Correlation Function estimation
  - Frame length N
  - Overlap O
- Wiener hopf equation: $\hat{R}\bar{a} = -\bar{\hat{r}}_x$
  - Inverting matrix
  - Levinson Durbin
- Wiener filtering in cascade
  - Prediction order P



# Simulation Results
## Optimal parameters

Questions?

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