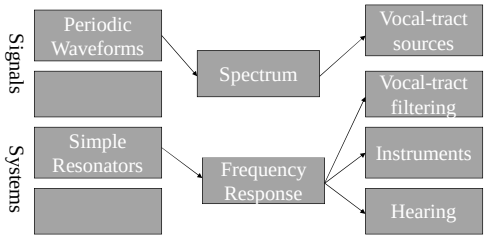
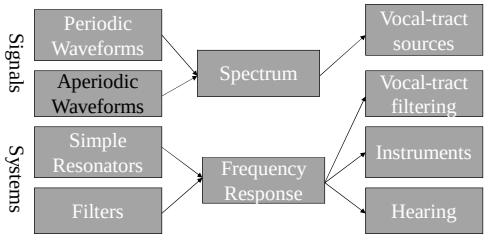
Acoustics of Speech and Hearing

Lecture 6
Noise & Filters

Progress



Progress



Overview

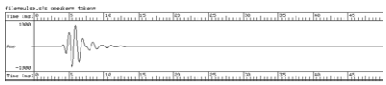
- Aperiodic signals
  - Spectrum of single pulse
  - Spectrum of noise
- Filters
  - For spectral analysis

Periodic and Aperiodic

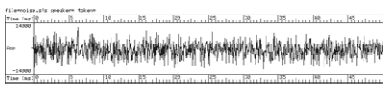
- Periodic
  - have regularly repeating waveform shape
  - have a measurable repetition period
  - have a measurable repetition frequency (=fundamental frequency)
  - have a spectrum made up from harmonics (=sinewaves at multiples of fundamental)

Periodic and Aperiodic

- Aperiodic Signals
  - Either: one-off events

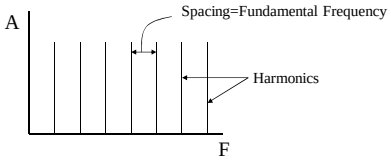


  - Or: random series of events



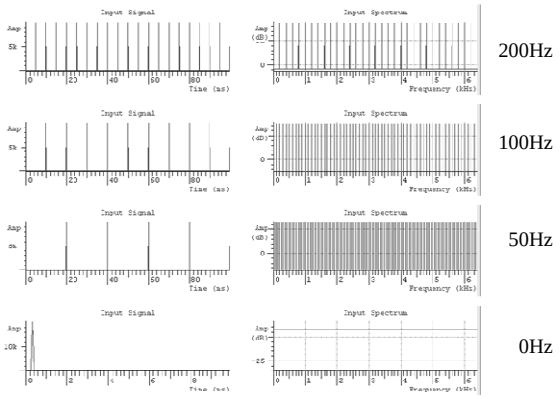
Spectrum of a Pulse

- What does the spectrum of a single pulse look like?
- We know what the spectrum of a pulse train looks like:



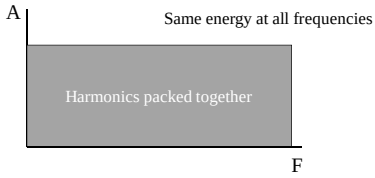
Spectrum of a Pulse

- Spacing between harmonics = size of fundamental frequency
- As we reduce the fundamental frequency, then, the harmonics get closer together
- At the point when pulses are 1 second apart, harmonic spacing is 1Hz
- At the point when the pulses are infinitely far apart (i.e. single pulse), spacing is 0Hz



Spectrum of a Pulse

- Spectrum of a single narrow pulse

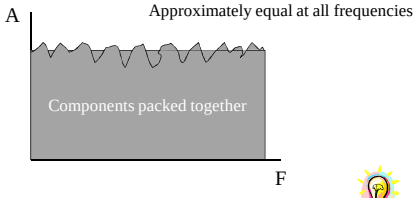


Spectrum of Noise

- Noise signal consists of a large number of independent sound sources
- Each vibrating at different frequency
- Therefore spectrum has energy at every frequency
- All have random phases with each other
- So spectral amplitudes fluctuate with time

Spectrum of Noise

- Spectrum of “white” noise



Filters

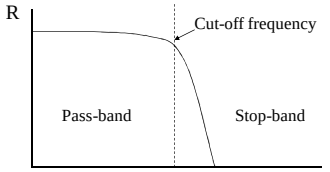
- Filter are useful systems
  - for processing signals
  - for analysing signals
- Filters have simply-described frequency response graphs
  - low-pass
  - high-pass
  - band-pass

Low-pass filter

- Low-frequency components of a signal pass through unchanged
- High-frequency components of a signal are attenuated
- Analogy: a coffee filter lets through small coffee particles, holds back larger coffee grounds

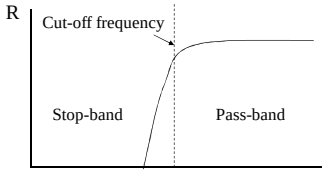
Low-Pass Filter

- Frequency Response



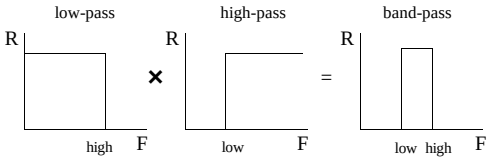
High-Pass Filter

- Frequency Response



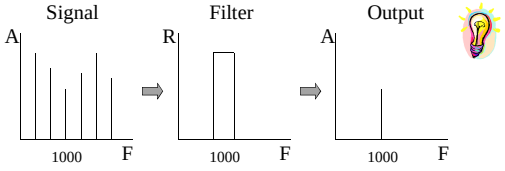
Band-Pass Filter

- Pass signal through combination of a high-pass and a low-pass
- Effectively passes only a single frequency region

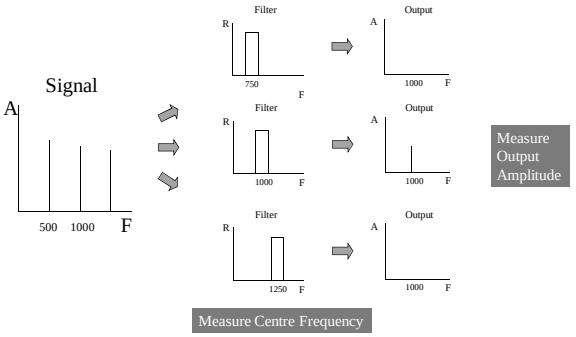


Band-Pass Filter

- Useful for analysis of a signal
- Tells us what components are present in a signal within a given band of frequencies

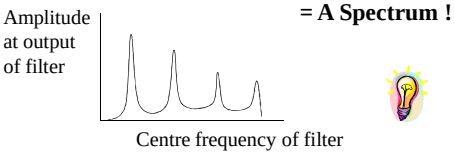


Bank of Band-Pass Filters



Band-Pass Filter

- Can use a *bank* of band-pass filters to analyse each frequency region in turn.
- Plot the output amplitude as a function of the band-pass filter centre frequency



= A Spectrum !

Summary

- Spectra of aperiodic waveforms
  - Spectrum of a narrow pulse
  - Spectrum of white noise
- Low-pass & high-pass filters
- Band-pass filters can be used to analyse signals

Lab Experiment

- Put together all signals & systems concepts
- Signals
  - Sinewave, pulse, pulse train, noise
- Systems
  - Amplifier, resonator, filter
- Signals through systems
  - Change in signal waveform
  - Change in signal spectrum