

CTP431: Fundamentals of Computer Music

# Digital Sound Synthesis Overview



Graduate School of  
Culture Technology

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# Category of Sound Synthesis

- Sample-based synthesis
- Abstract sound synthesis
- Physical modeling

# Sample-based Synthesis

- Use recorded samples
  - Require large memory
  - Natural tones but not flexible: pitch shifting by resampling
  - Concatenative synthesis: e.g. singing voice synthesis
  - Granular Synthesis



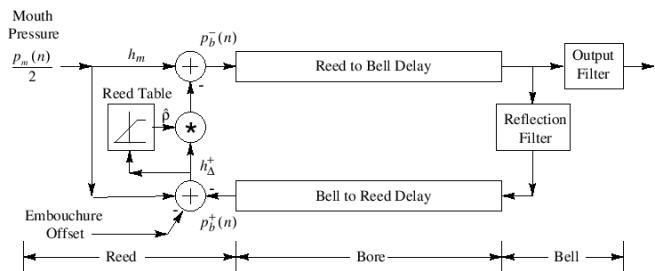
# Abstract Sound Synthesis

- Use “digital” (or band-limited) oscillators and modifiers (digital filters)
  - Highly parametric and programmable
  - Additive: a collection of sine oscillations
  - Subtractive: harmonic oscillator (sawtooth, square) + filter
  - Modulation: frequency modulation
  - Distortion: sine + distortion



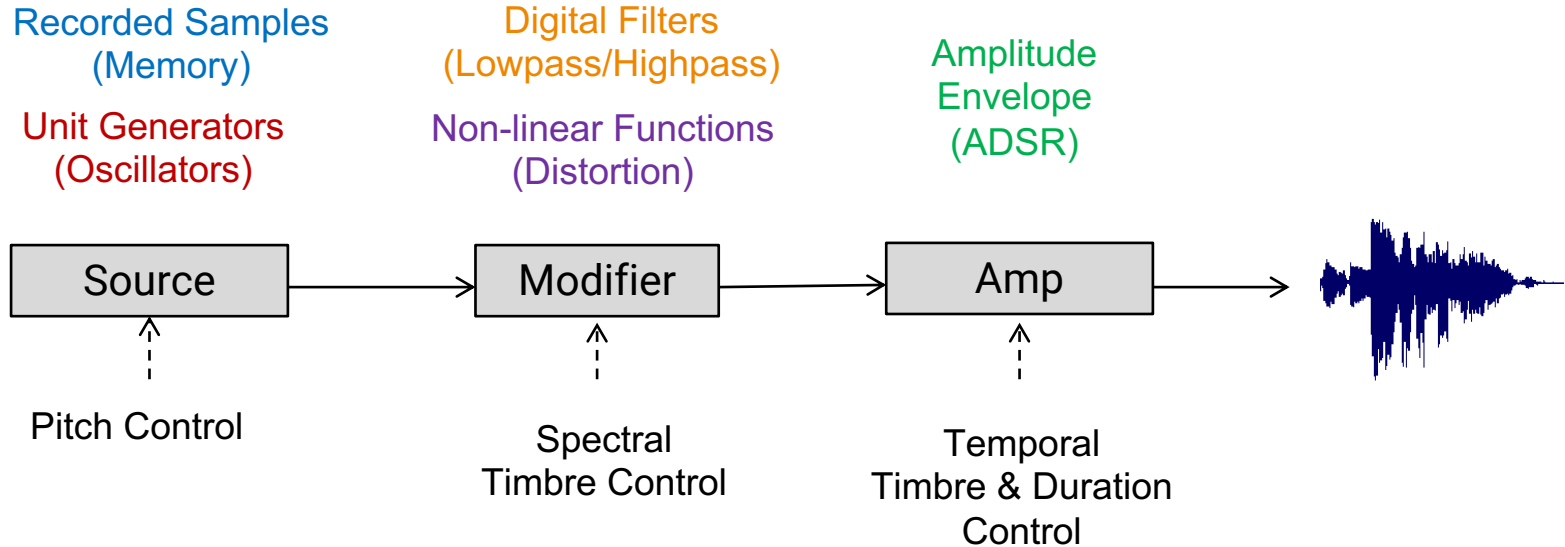
# Physical Modeling sSynthesis

- Imitate the physical phenomenon of vibrating objects
  - Numerical modeling of wave equations: e.g. finite difference
  - Digital waveguide: efficient model based on delaylines
  - Physically interpretable parameters



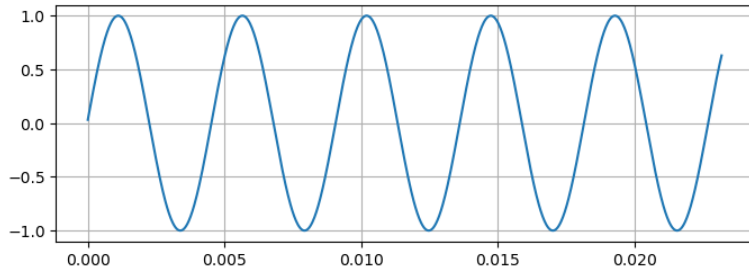
# Tone Generation on Computer

- General framework

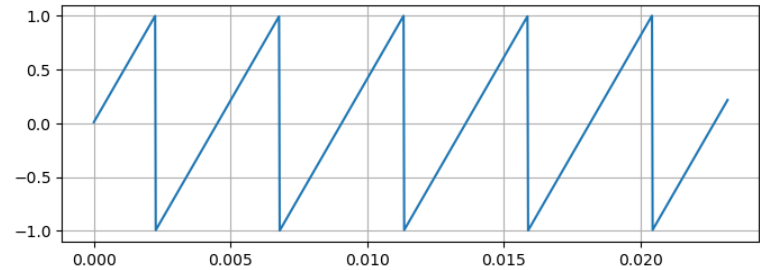


# Unit Generators

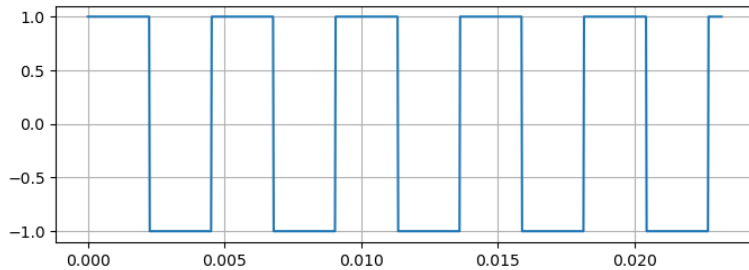
- Generate oscillators with classical waveforms
  - Parameters: frequency, pulse width (square osc)



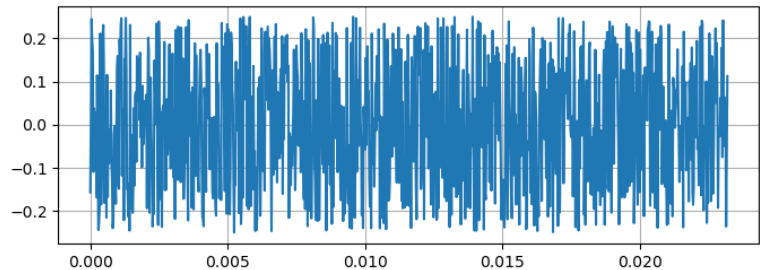
Sine



Sawtooth



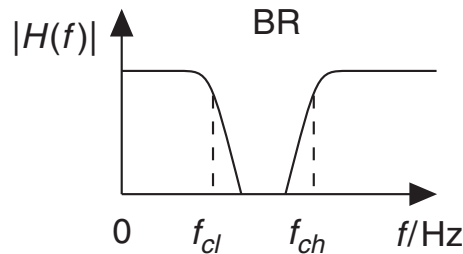
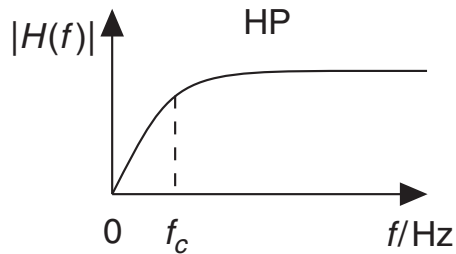
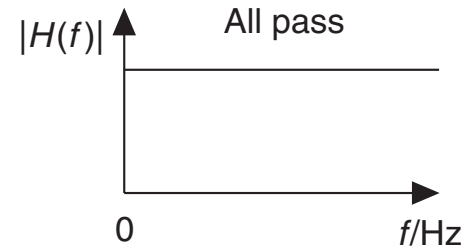
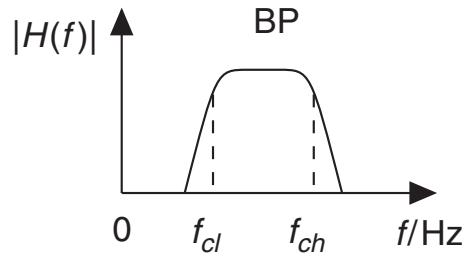
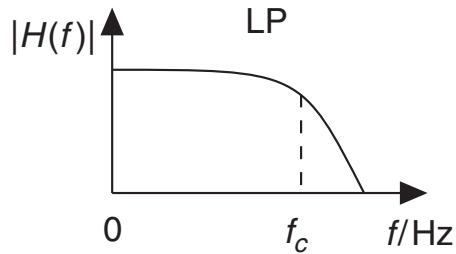
Square



Noise

# Filters

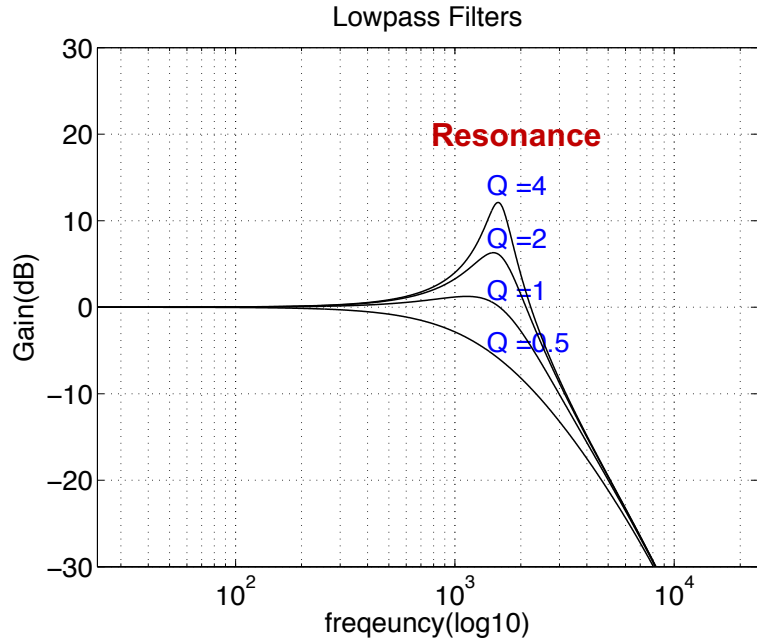
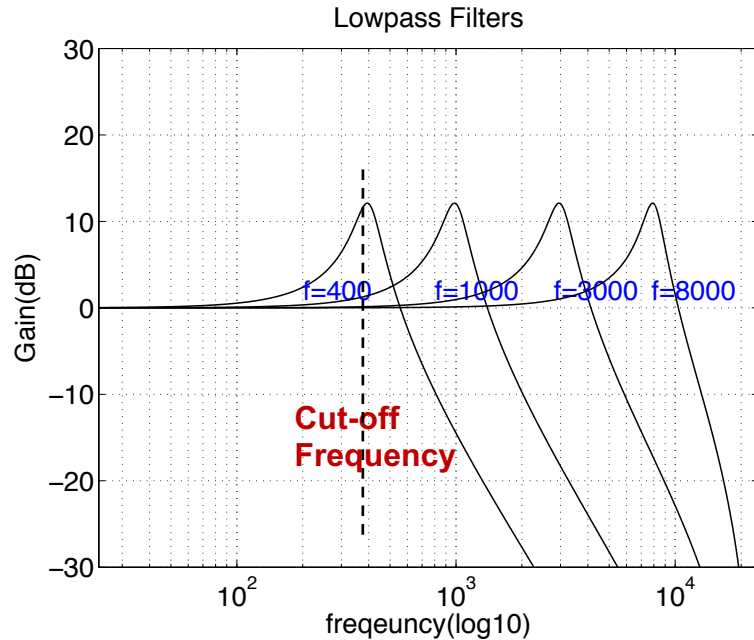
- Control the frequency response of the source signals
  - Types: lowpass, highpass, bandpass, bandreject (notch)
  - Parameters: cut-off/center frequency,  $Q$





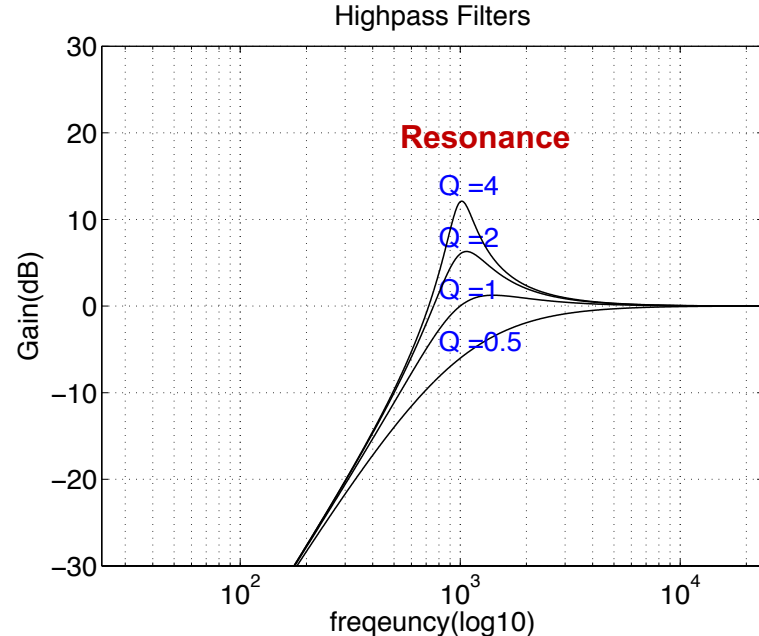
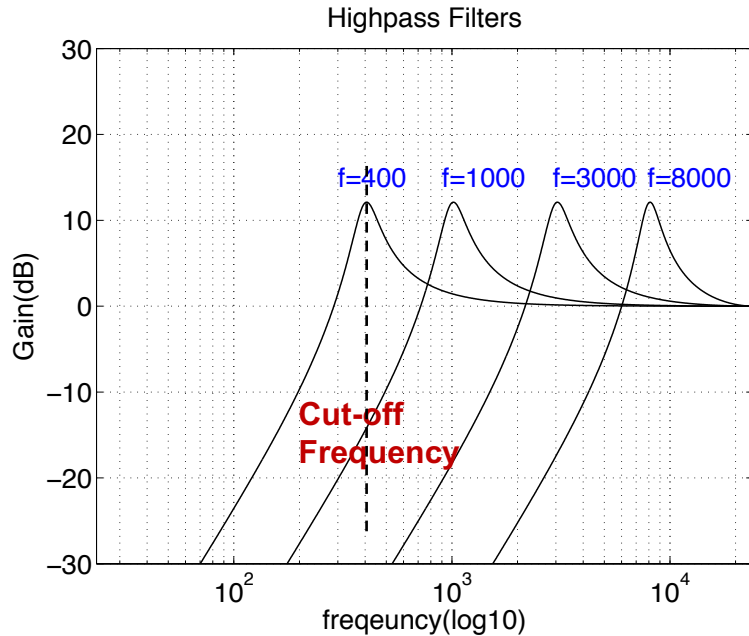
# Resonant Lowpass Filter

- Suppress high-frequency content
  - With a resonance at the cut-off frequency



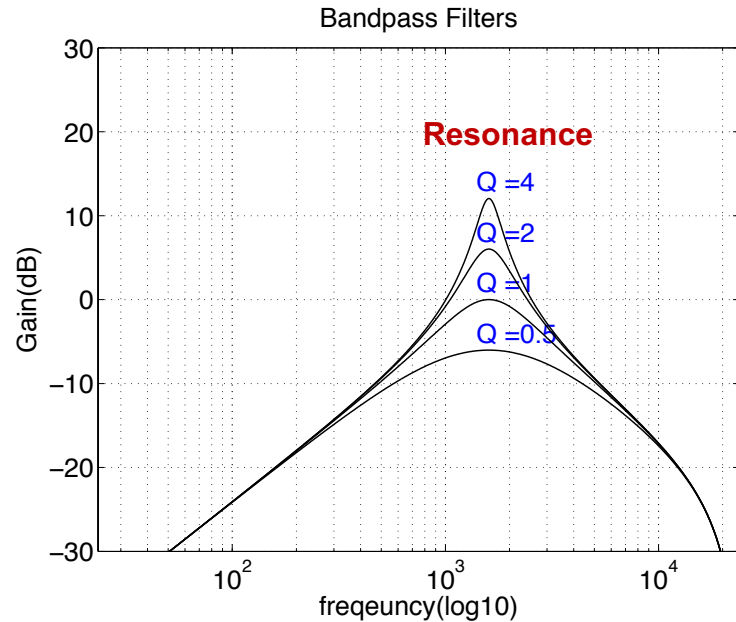
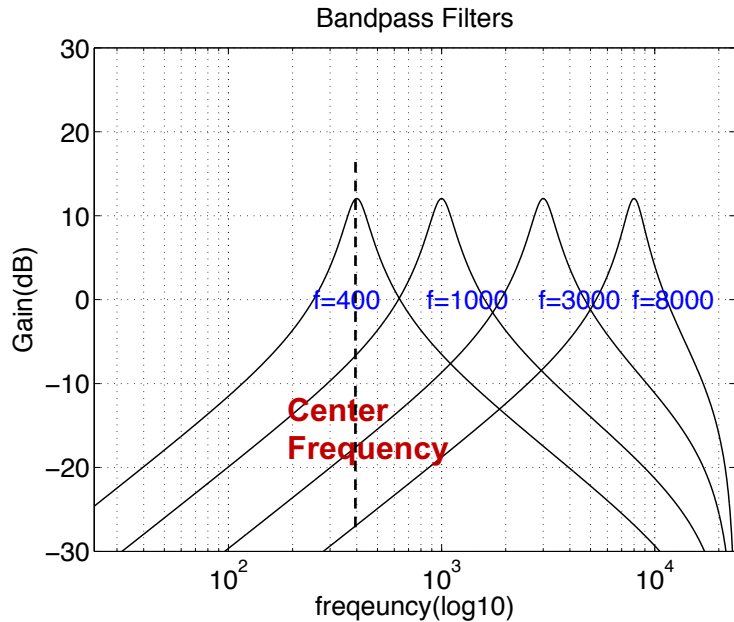
# Resonant High-pass Filter

- Suppress low-frequency content
  - With a resonance at the cut-off frequency



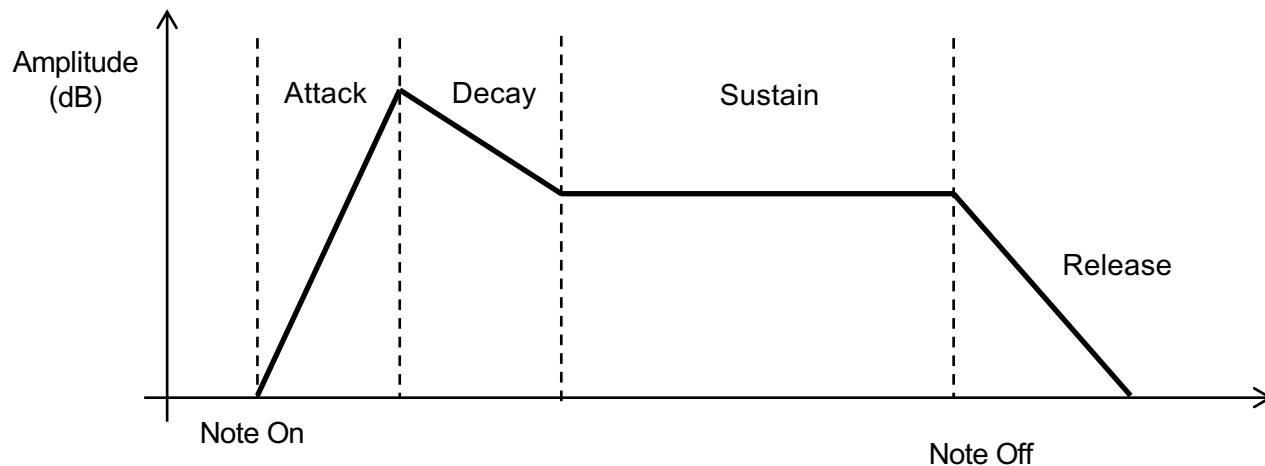
# Bandpass Filter

- Suppress both low and high frequency content
  - Preserve the content around the center frequency



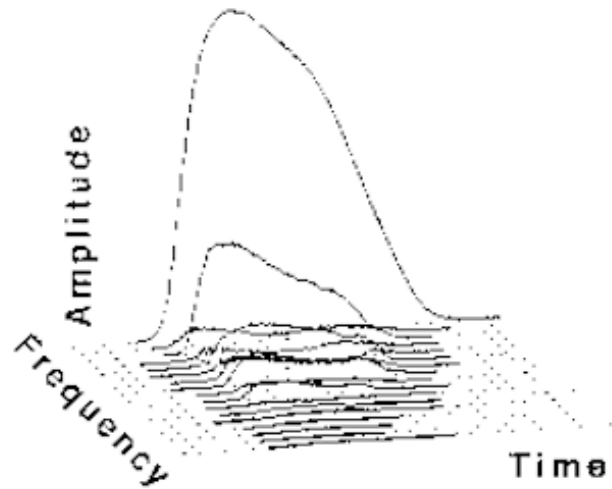
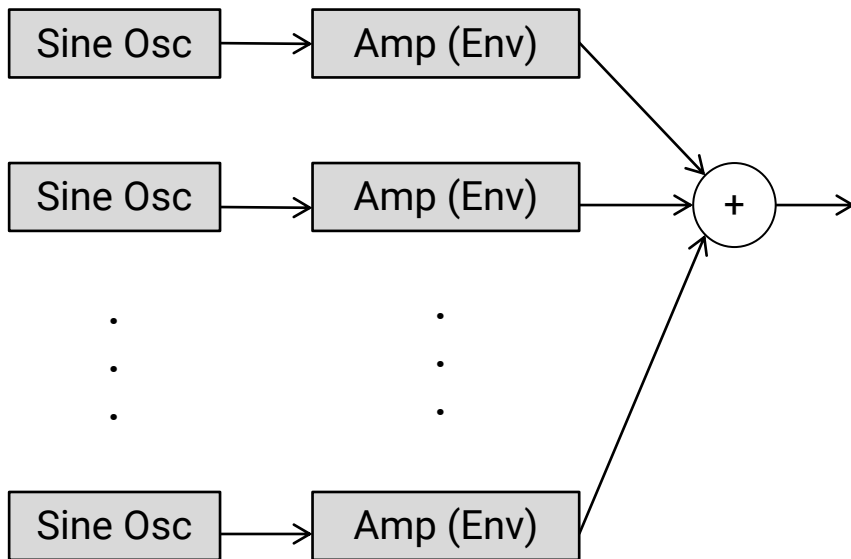
# Amplitude Envelop Generator

- ADSR curve
  - Attack time, decay time, sustain level, and release time



# Additive Synthesis

- Synthesize sounds by adding multiple sine oscillators
  - The frequencies of sine oscillators are arbitrary: synthesize inharmonic tones



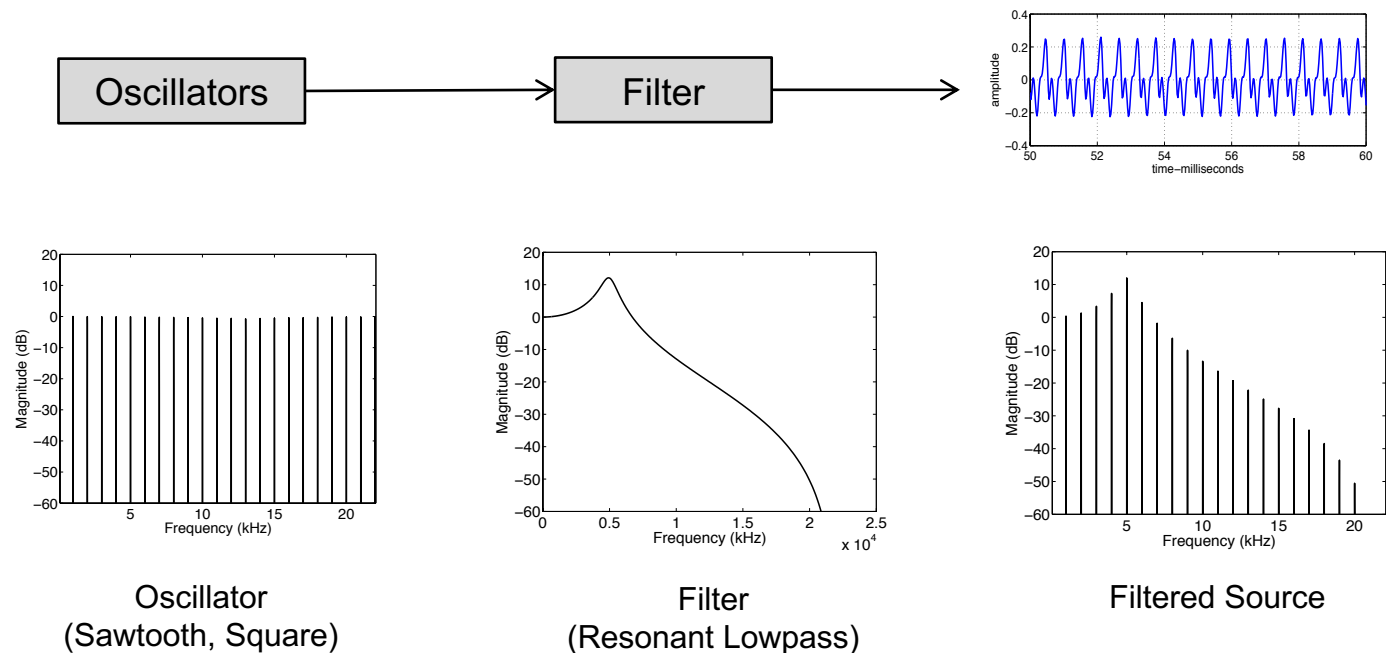


# Examples

- Organ
  - <https://www.vdveen.net/webaudio/hammond/hammond.htm>
- Bell
  - <https://aatishb.com/synthesine/examples/bell-additive/index.html>

# Subtractive Synthesis

- Synthesize sounds by filtering wideband oscillators





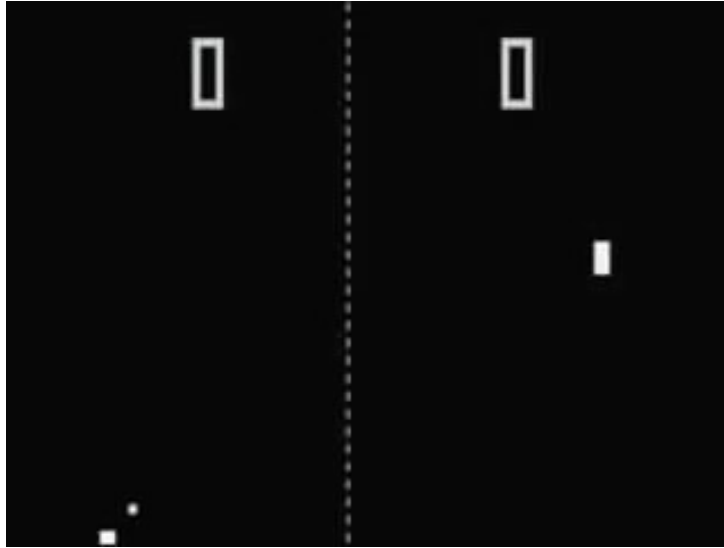
# MiniMoog

- Analog synthesizer



# Retro Game Sounds

- Atari Pong (1972): the “beep” sounds
  - Early game sound effect
  - Use existing square waveforms in the circuit



# Nintendo Entertainment System Chiptunes



<https://www.youtube.com/watch?v=la3coK5pq5w>

# Drum Machine

- Rhythm machine
  - Unique electronic drum kit sound and step sequencer



Roland TR-808

<https://www.youtube.com/watch?v=GZeVAR7d9TA>

Web version

<https://io808.com/>

# Examples

- Web Audio Demos
  - <http://aikelab.net/websynth/>
  - <http://nicroto.github.io/viktor/>
  - <https://www.vdveen.net/webaudio/minimoog/mm.htm>
- Well-known sounds
  - SuperSaw
  - Leads
  - Pad
  - Bass
  - 8-Bit sounds (80's game)
  - TR-808 (Drum machine)

# More resources

- <https://learningsynths.ableton.com/en/playground>
- <https://learningmusic.ableton.com/index.html>