Foundations of Audio Engineering:
Audio signal processing - 2

Nimal Skandhakumar

Faculty of Technology
University of Sri Jayewardenepura

2020

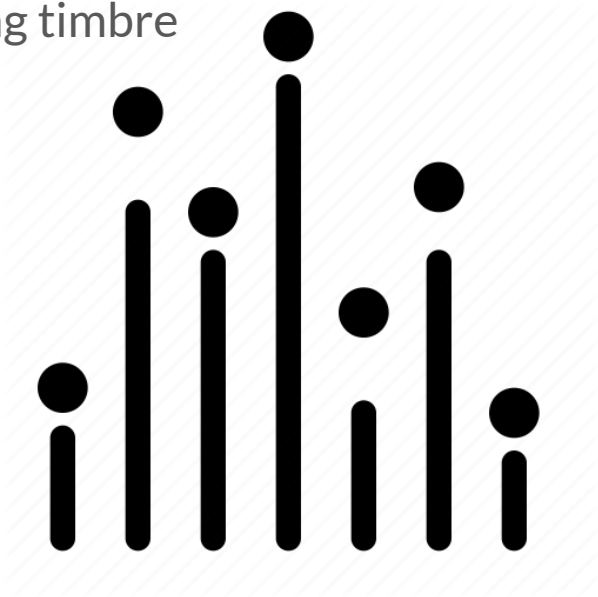
Partially based on:

- Christopher Ariza. 21M.380 Music and Technology: Recording Techniques and Audio Production. Spring 2012. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
- Digital Audio Production IT3038PA, NITEC Digital Audio & Video Production. 2013. Institute of Technical Education College West.

Frequency-based Signal Processors

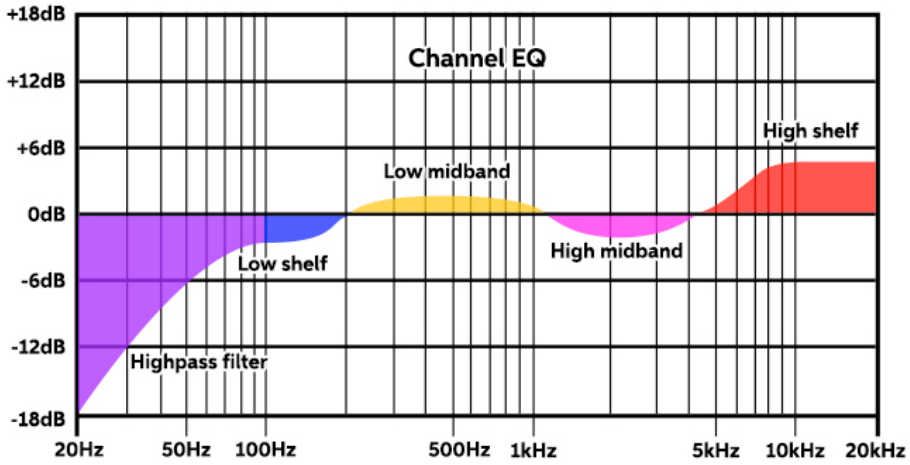
Processors that Shape Frequencies

- Shaping timbre is not the same as transforming timbre
- Shaping timbre
  - Filters
  - Aural exciters and enhancers
  - Bass processors
- Changing and adding frequencies
  - Pitch shifters
  - Harmonizers



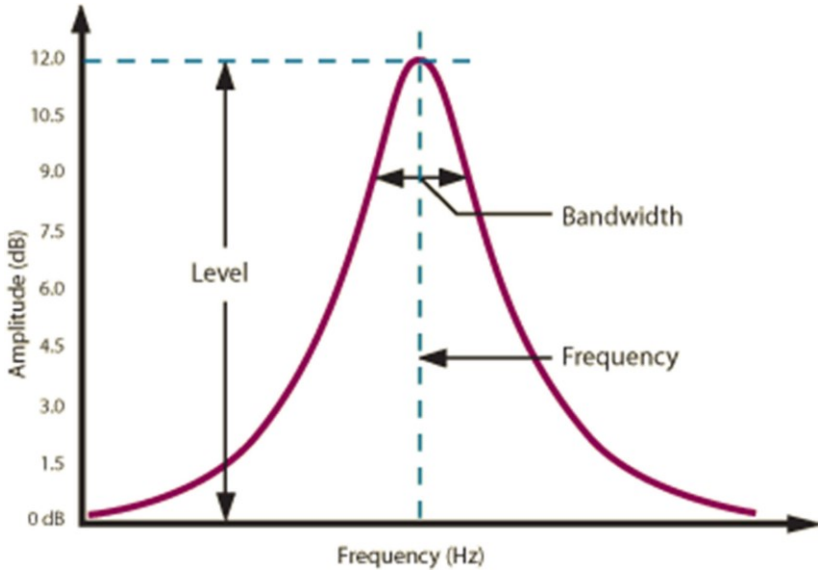
Equalizers and Filters

- Equalizers (EQ) are filters
  (a distinction is not useful)
  - selectively boost or attenuate frequency regions
  - cannot add frequencies that are not present in the source
  - mixing out of phase signals can cause filtering



Filter Parameters and Units

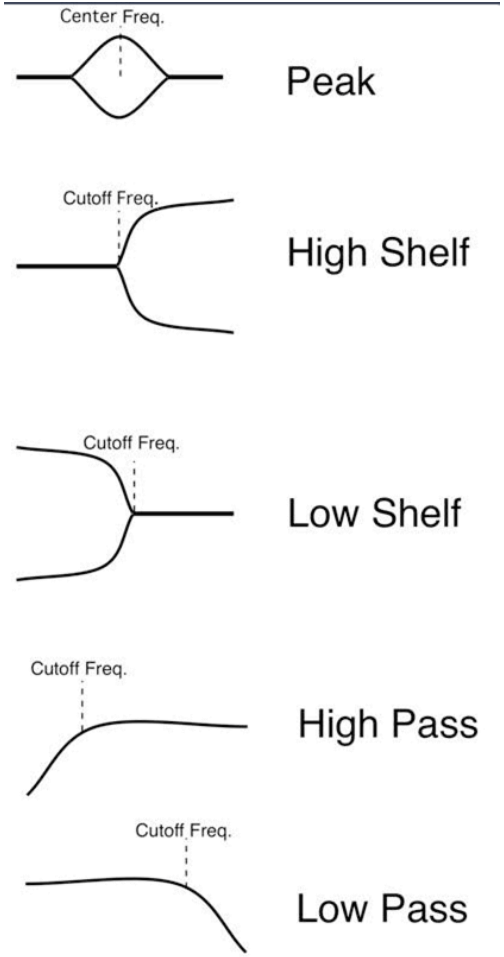
- Gain:
  - 0 dB is no change (unity); otherwise, may be positive or negative
- Rolloff:
  - slope, a change in gain over frequency measured in dB / octave
- Bands and bandwidth:
  - measured in octaves or Q
- Center and cutoff frequency:
  - Hertz



Filter Types and Parameters

- Low/High Pass, High/Low Cut:
  - cutoff frequency, rolloff
- Low/High shelves:
  - cutoff frequency, gain, Q
- Parametric (peak/notch) filters:
  - center frequency, gain, Q

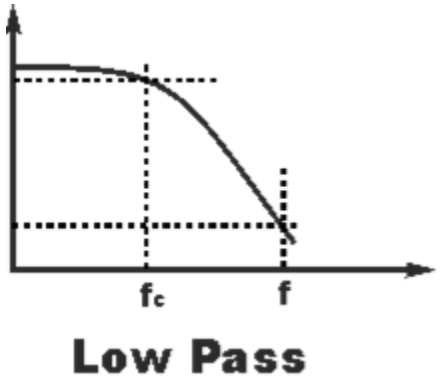
https://www.soundonsound.com/techniques/using-your-sequencers-equalisers



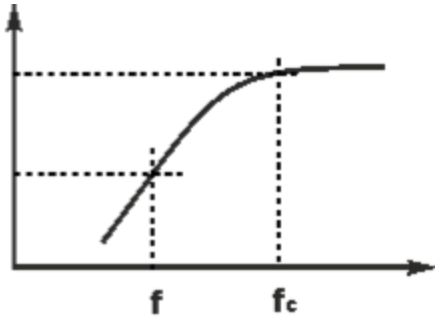
Low/High Pass, High/Low Cut

- Cutting narrow ranges at the top or the bottom of the spectrum
- The most simple (and extreme) filter
- Parameters:
  - cutoff frequency, rolloff
- Types:
  - Low pass, high cut filter
  - High pass, low cut filter

https://www.youtube.com/watch?v=JndvN1ngSi4



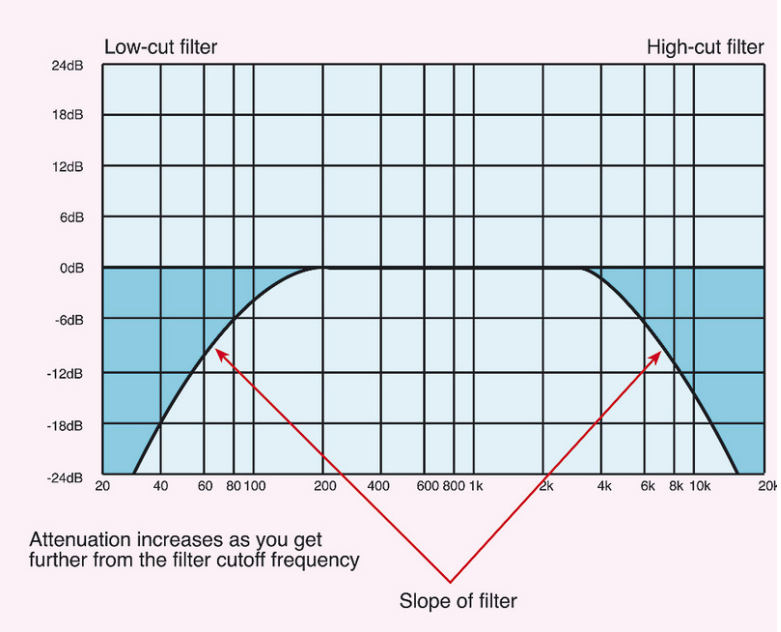
Low Pass



High Pass

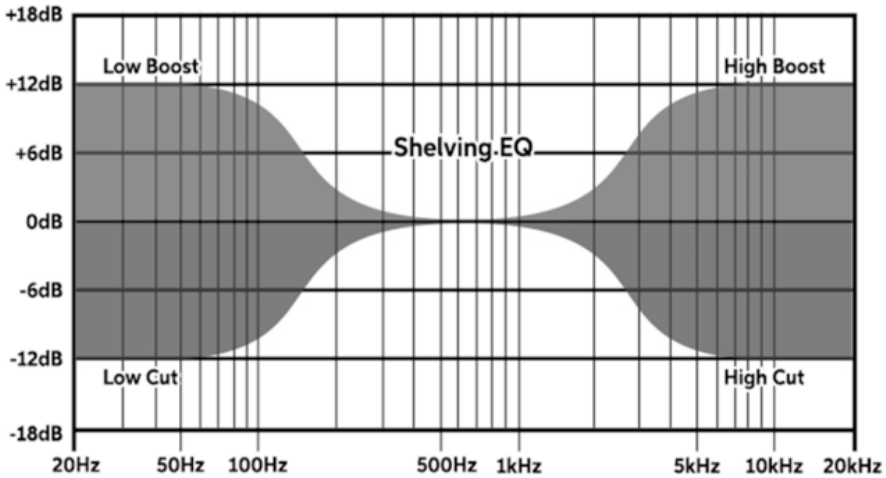
Low/High Pass, High/Low Cut

- Removing high frequency noise or buzz
- Removing low frequency stage noise, machine noise, hum
- Isolating one frequency region (combining both low and high pass) to remove leakage
- Removing super-low frequency signals from digital instruments
- Be careful to avoid removing essential harmonics (low pass)



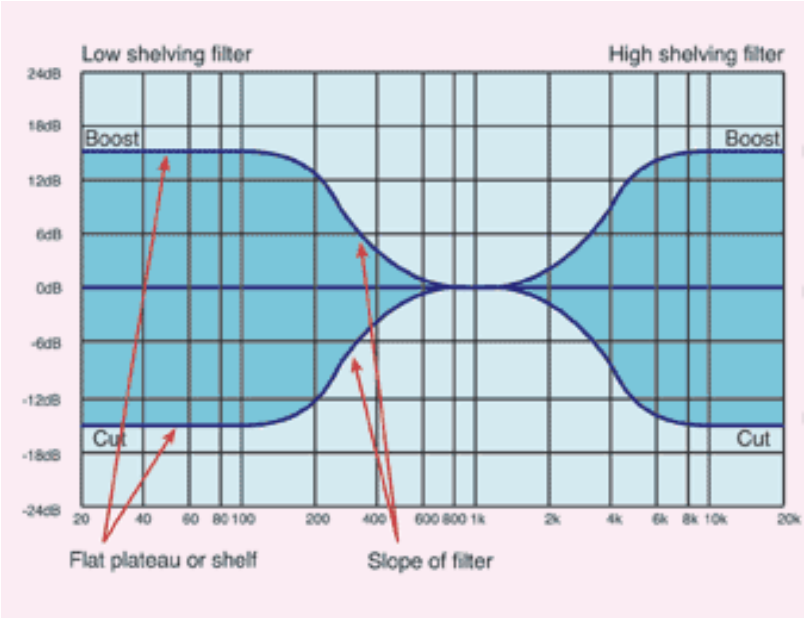
Low/High Shelves

- All frequencies above or below a certain point are boosted or attenuated by the same amount
- Coarse, broad filters
- Parameters:
  - Cutoff frequency, Gain, Q (sometimes)



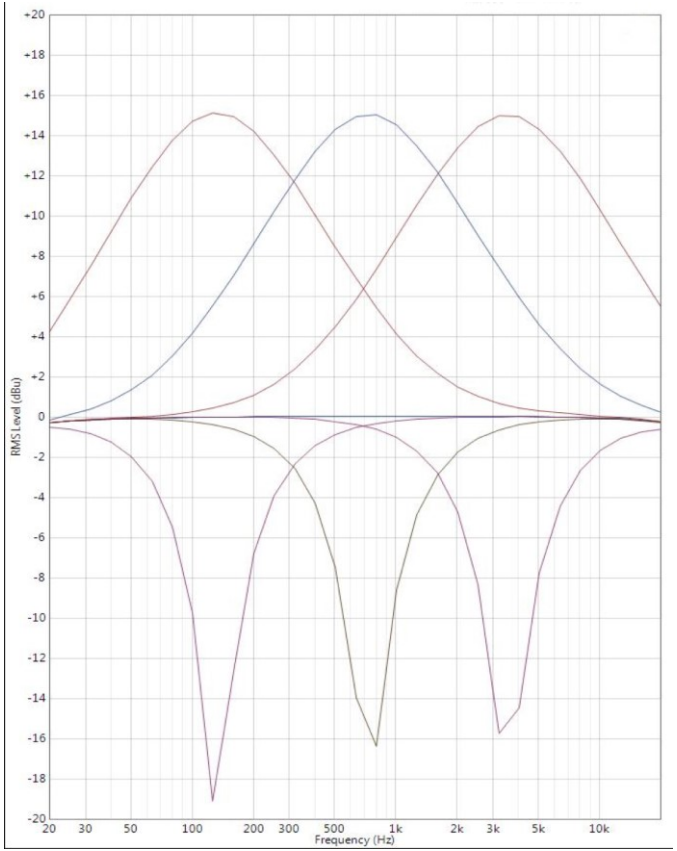
Low/High Shelves

- Correcting for a general deficiency in a microphone or recording:
  - too little or too much bass/treble
- Boosting upper harmonics or the air band (high shelf)
- Avoid boost on low-end; be careful about boosting low frequencies you are not hearing (low shelf)



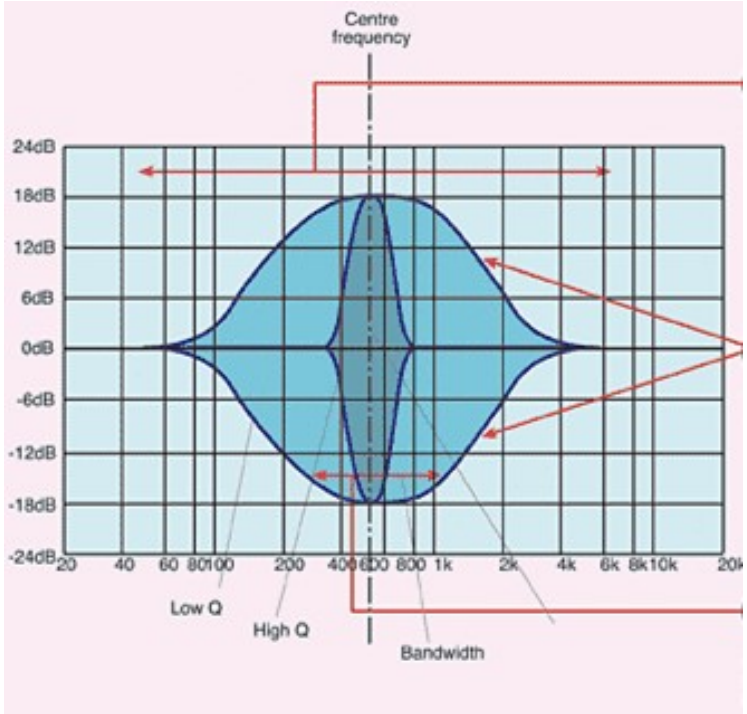
Parametric Equalizers

- Boosts or attenuates a range of frequencies centered around a certain point
- Alternative names:
  - peak / notch filter, peaking filter, bell EQ
- Parameters:
  - center frequency, bandwidth (Q), gain
- Some parametric filters may not allow some or all three parameters to be changed
  - Semi-parametric, Two-parameter, One-parameter



Parametric Equalizers

- Extremely narrow bandwidth boosts will result in pitched-overtones
- Favor boosting with broad bandwidths to shape regions of harmonics/fundamentals
- Narrow bandwidth cuts can be used to remove noise, feedback, or other undesirable artifacts
- Favor broad-bandwidth parametric for low-frequency boosts over a low-shelf boost



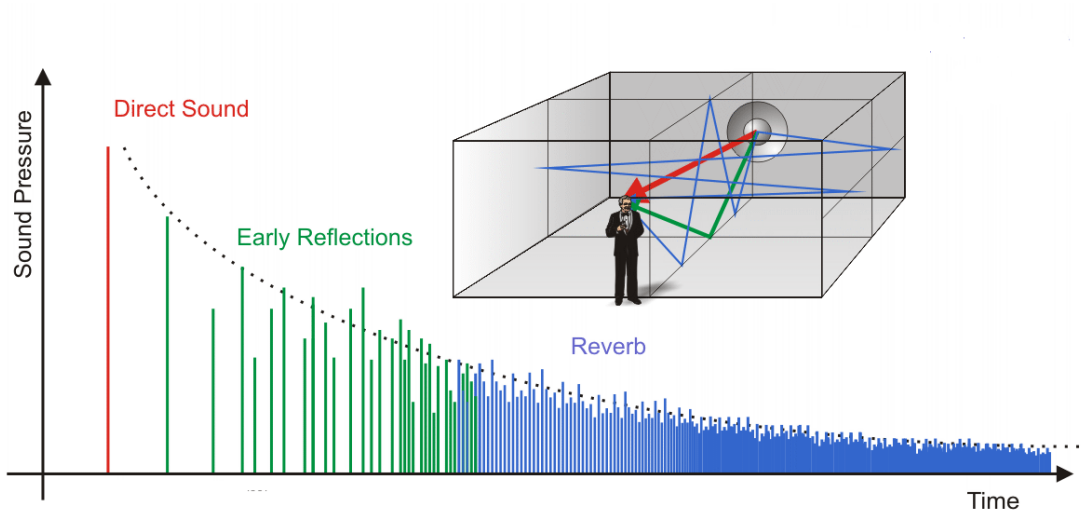
Graphic Equalizers

- Numerous one-parameter parametric filters
- Distributed across the frequency range in equal octave segments
- Common center frequency spacings:
  - 1/3 octave, 1/6 octave
- Used for live sound engineering, tuning rooms, avoiding feedback

Time-based Signal Processors

Time-Based Processors

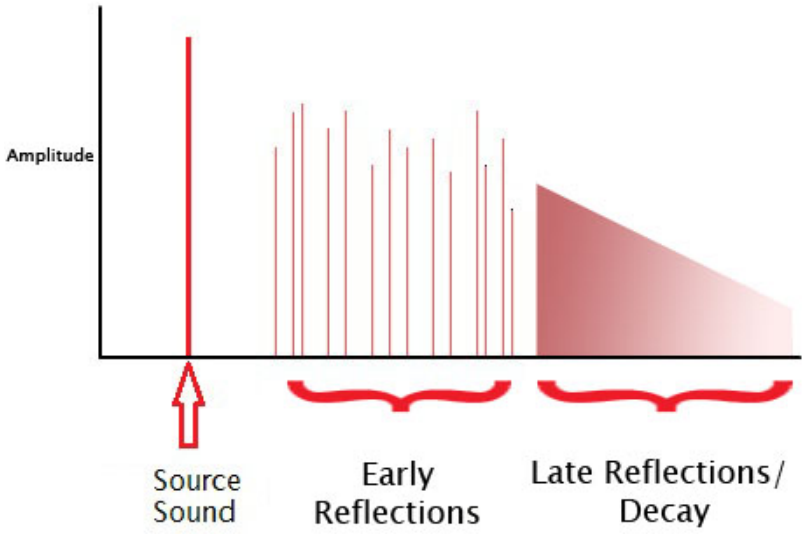
- Reverbs
- Delays
- Flangers, chorus, and phasing



https://ledgernote.com/columns/mixing-mastering/delay-audio-effect/

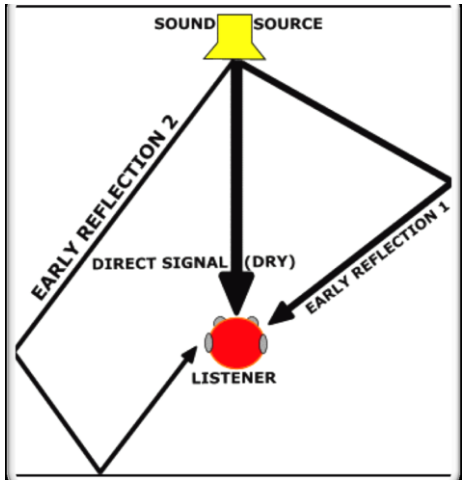
Time-Based Processors

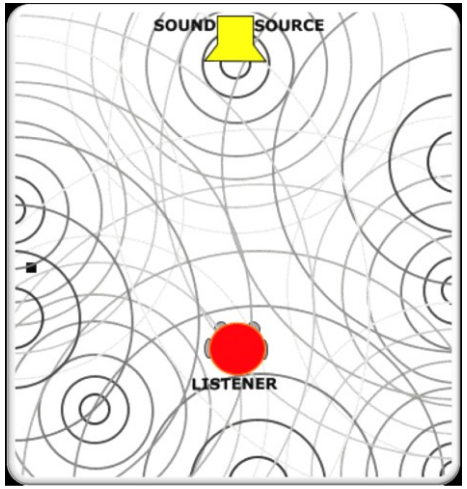
- Common Attributes
  - All employ delays
  - All are often processed in parallel (with an auxiliary track or with mix controls)
  - All are often best used in stereo rather than mono
  - All are easily over-used



Acoustic Reverberation

- When we hear sound, we hear a mix of:
  - Direct (dry) sound
  - Individual reflections (early reflections) from nearby hard surfaces.
  - Other reflections so closely spaced and overlapping that our brain can't perceive them as separate.

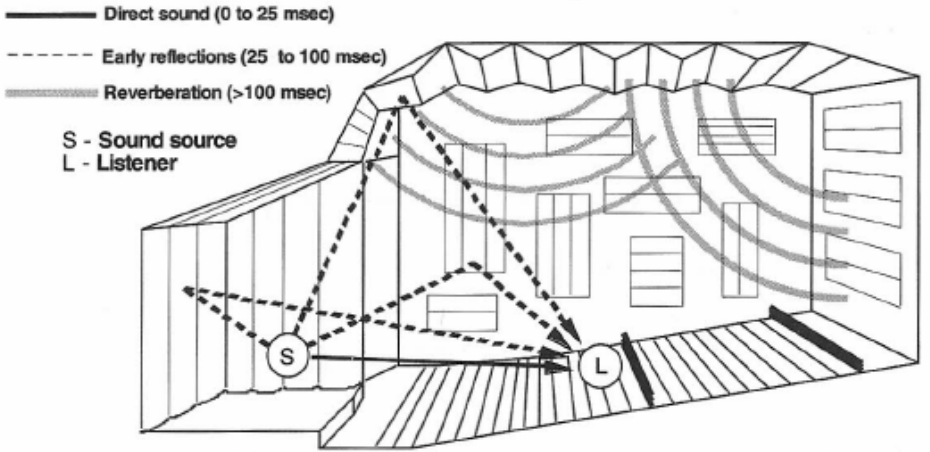




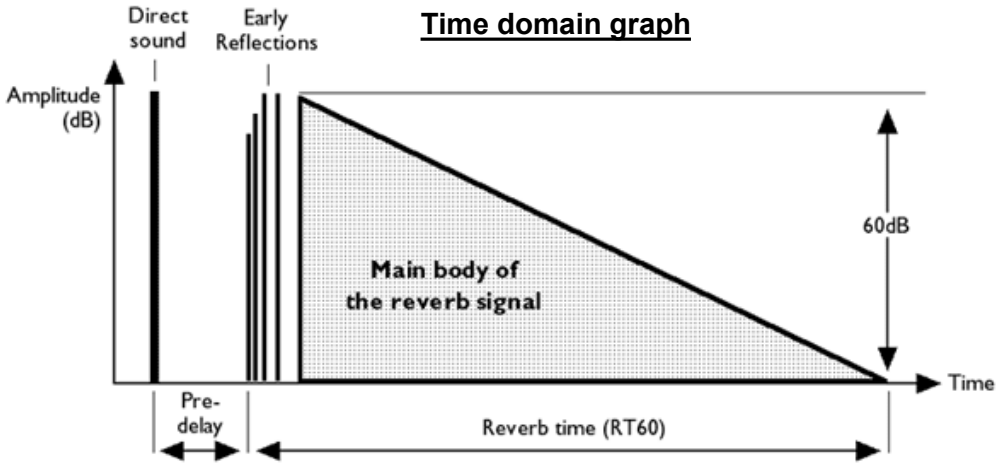
https://wiki.audacityteam.org/wiki/Principles_of_Reverb

Reverb Processors

- Why use reverb processors?
  - Coherence: reconnecting tracks recorded in isolation or without space
  - Recreating an acoustic space
  - Special effects



Reverb Parameters



- Decay:
  - duration of reverberations
  - time of tail to fall -60 dB
- Size:
  - color or type of diffusion algorithms
- Pre-Delay:
  - time before reverb starts
  - a bit (30 ms) is generally needed to get reverb away from dry signal
- Early reflections
- Diffusion
- Wet / dry mix

Spring Reverb

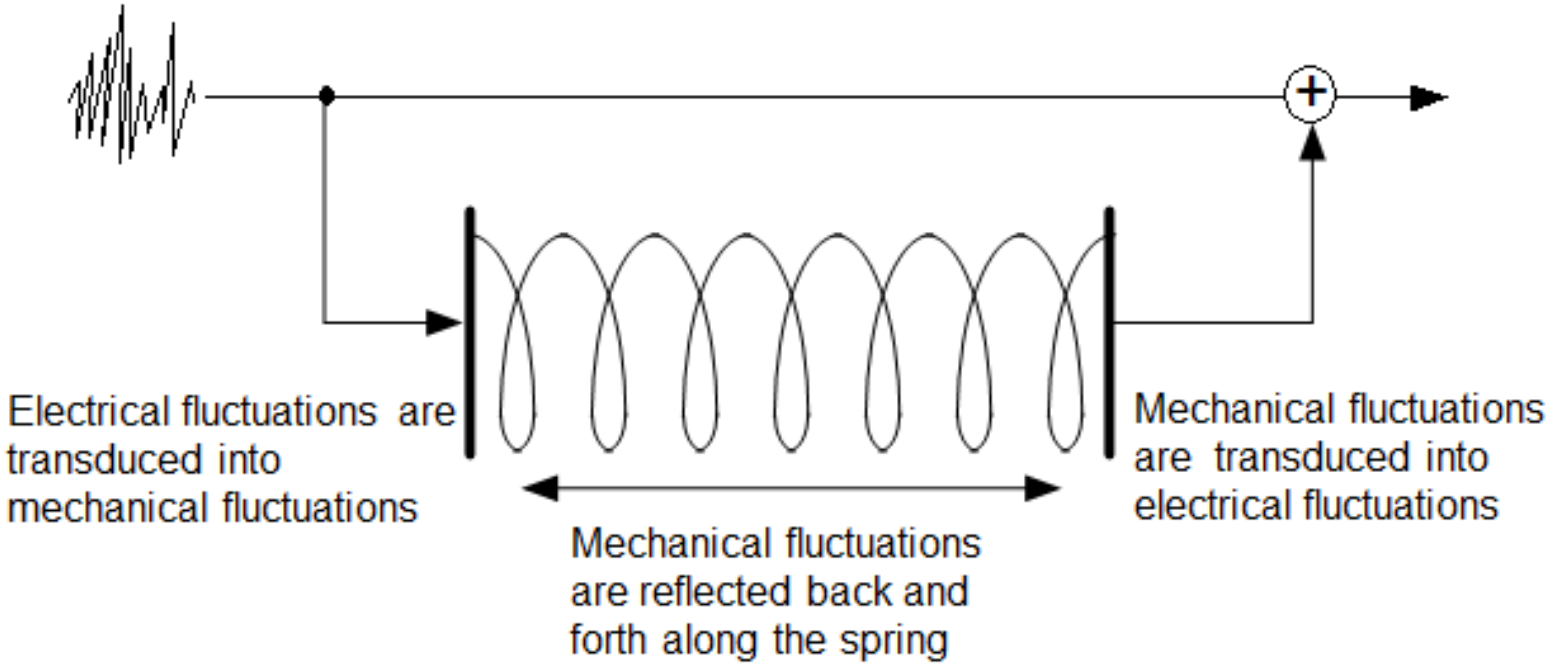
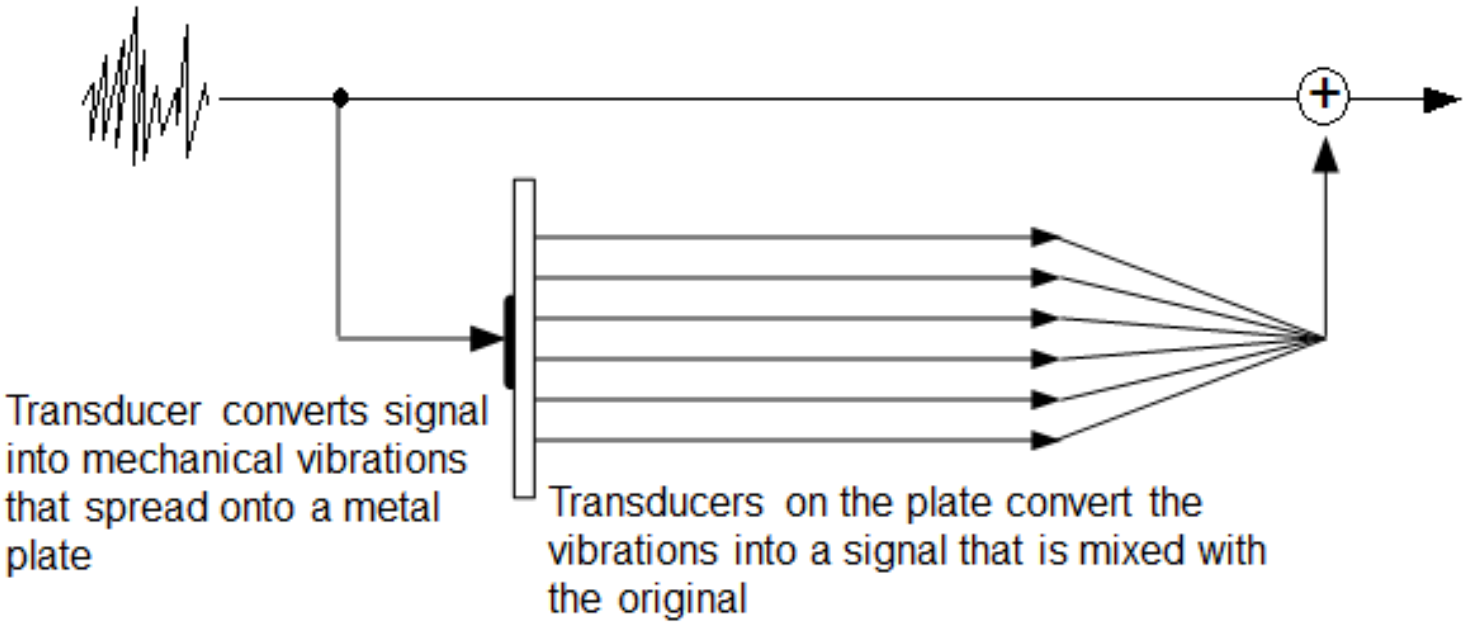


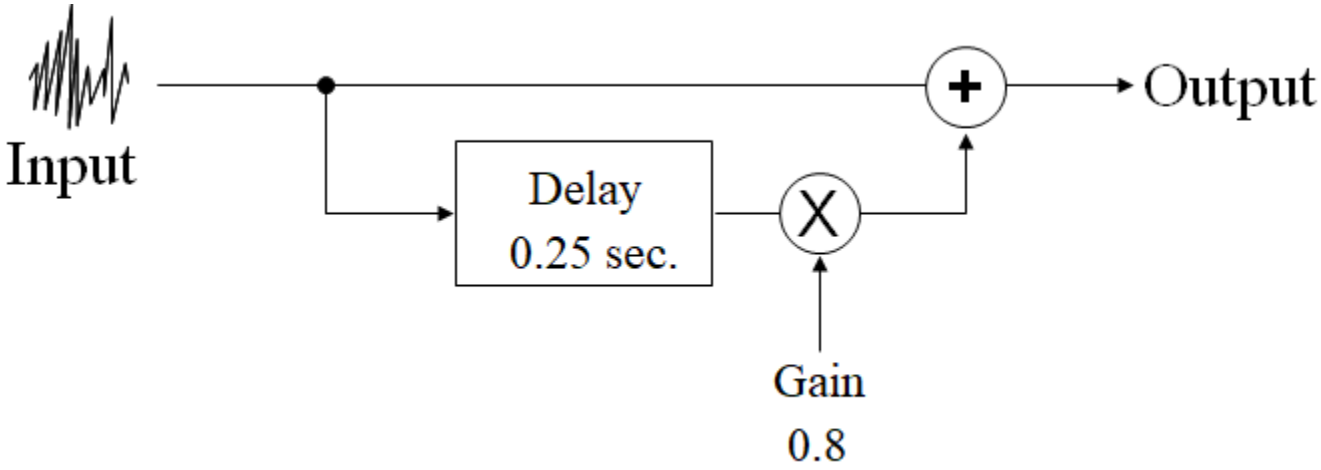
Plate Reverb



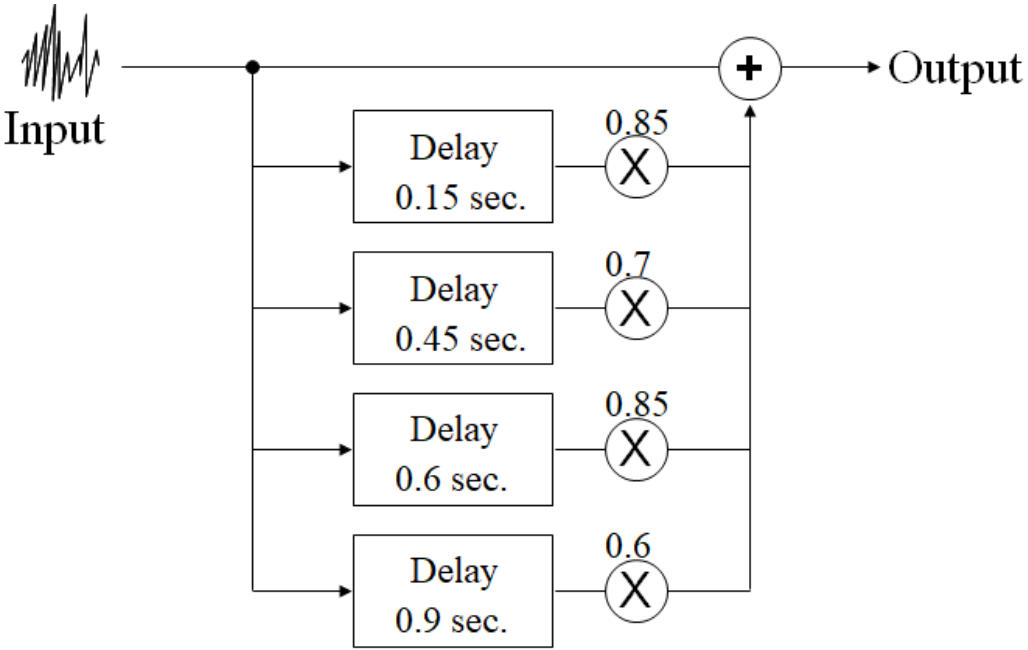
Time Delays

- Records an input signal to an audio storage medium, and then plays it back after a period of time.
- The delayed signal may either be played back multiple times, or played back into the recording again, to create the sound of a repeating, decaying echo.
- The most basic type of effect is simple delay.
  - Delay > 50 ms: audible echoes
  - Delay < 10 ms: coloration, filtering
  - Between, enhancement, increase in volume

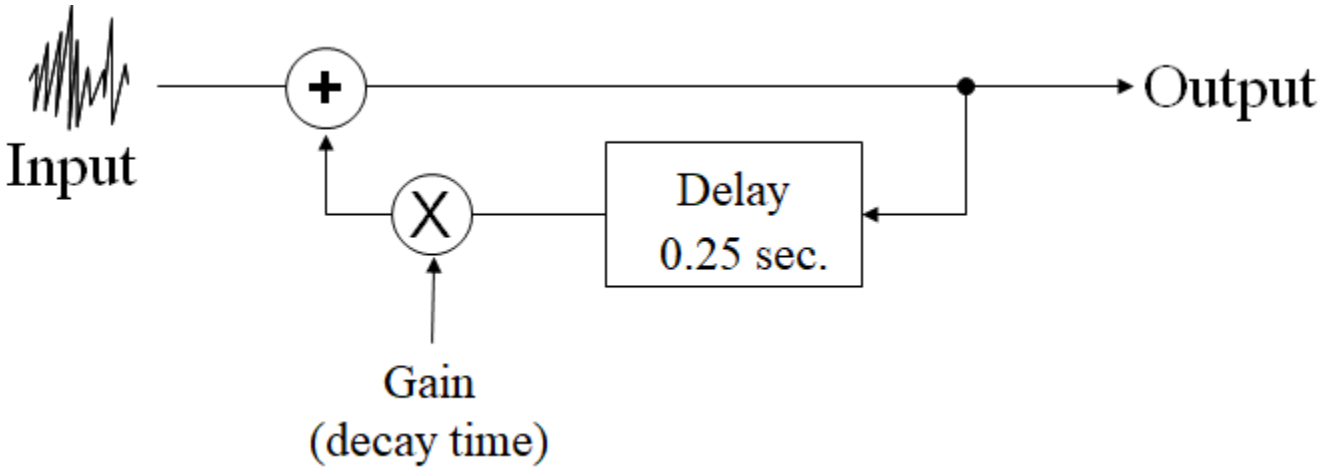
Simple Delay



Multitap Delay

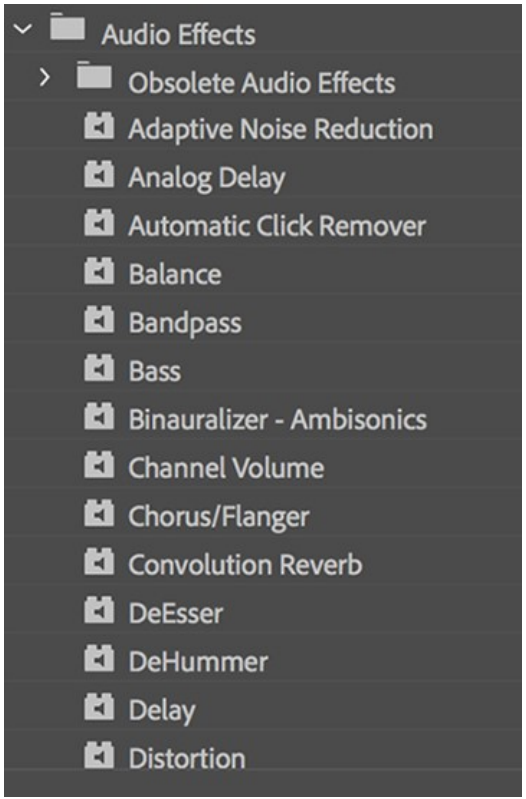


Feedback Delay



Other Sound Effects Processors

- Auto Tune
- Pitch Bend
- Phasing & Flanging
- Vibrato
- Chorus



https://blog.landr.com/audio-effects-plugins-guide/

Further Learning

- What are Audio Effects?
  - https://www.youtube.com/watch?v=NJ2WzLg5rDc
- Reverb and Delay Explained
  - https://www.youtube.com/watch?v=-jPPJEHMepA
- EQ Explained
  - https://www.youtube.com/watch?v=I6ZF_NHvqzU

Practicals