21M.380 · Music and Technology
Recording Techniques & Audio Production

Filters & EQs

Session 8 · Monday, October 3, 2016

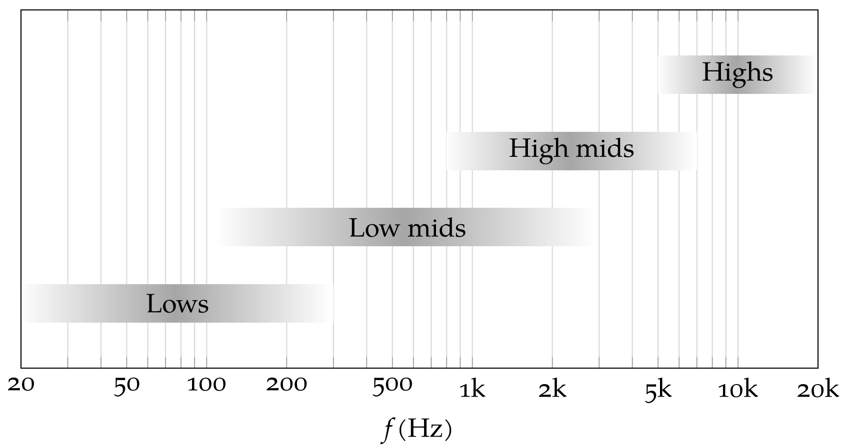

Figure 1. The basic four-band division of the audible frequency spectrum (after Izhaki 2011, fig. 14.3)

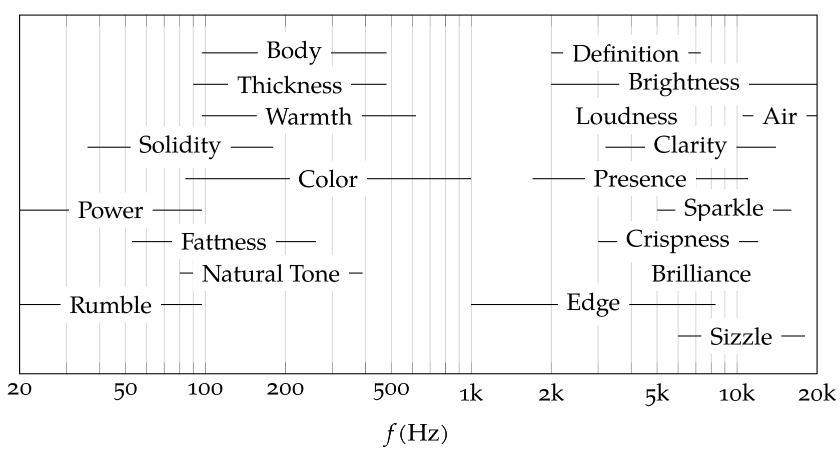

Figure 2. Qualitative descriptions of various frequency ranges (after Izhaki 2011, fig. 14.4)

1 Student presentation (PA1)

- [redacted]

2 Announcement: Recording sessions

- Still looking for volunteering musicians for 11/14 and 11/30 sessions
- Ideas are welcome!

3 Filtering the frequency spectrum

- Waveforms are great to visualize and edit sound in the time domain.
- But what about editing the spectrum (frequency content) of sound?
- *Filters* selectively amplify or attenuate certain frequencies ranges.
- Filters don't add frequencies that are not already present in the source! They are sound *processors* rather than generators.
- A filter is best described by its *frequency response*:[1]
  - Constant frequency response at 0 dB … equivalent to piece of wire
  - Constant frequency response at +3 dB … +3 dB amplification
  - But we're primarily interested in treating frequencies *differently*!
- E.g., combination of filters can be used to *equalize* uneven response
- But ironically, EQs are often used to deliberately *un*equalize frequencies!
- Everything is a filter! EQs, rooms, analog circuits, speaker cabinets, …

[1] The *frequency response* of a filter describes its gain as a function of frequency.

4 Filter types & parameters

Filter type	Parameter	Symbol	Unit	Definition
Cut	Cut-off frequency	f_c	Hz	at −3 dB point
	Slope (or roll-off)	—	dB/octave	—
Shelving	Gain	g	dB	max. amplification or attenuation
	Center frequency	f_c	Hz	at $g/2$
Peaking	Gain	g	dB	max. amplification or attenuation
	Center frequency	f_c	Hz	at g_{max}
	Bandwidth	Δf	Hz	between −3 dB (or +3 dB) points
	Quality (or Q factor)	Q	1	$Q = f_c/\Delta f$

Table 1. Filter parameters

4.1 Cut filters

- Low-cut (or high-pass) vs. high-cut (or low-pass) filters
- *Cut-off frequency* f_C at −3 dB (*not* −6 dB!) by definition
- *Slope* or *roll-off* (dB per octave)[2]

[2] Remember that an octave is defined as the frequency ratio $f_1 : f_2 = 1 : 2$, e.g, there is an octave between 30 and 60 Hz or between 1 and 2 kHz.

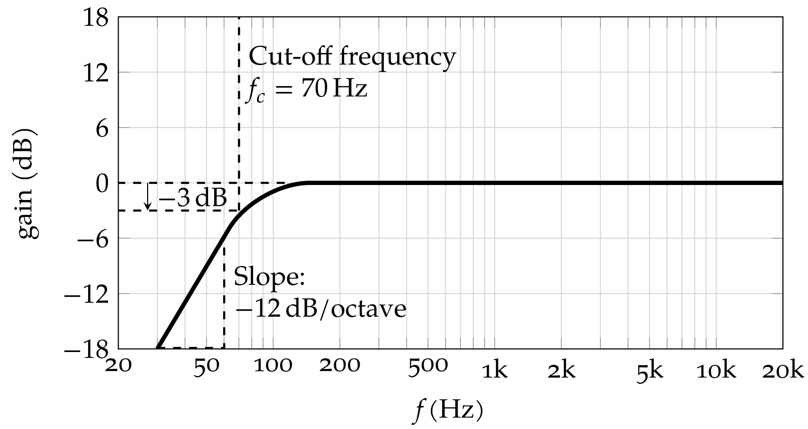

Figure 3. Frequency response of a low-cut (high-pass) filter

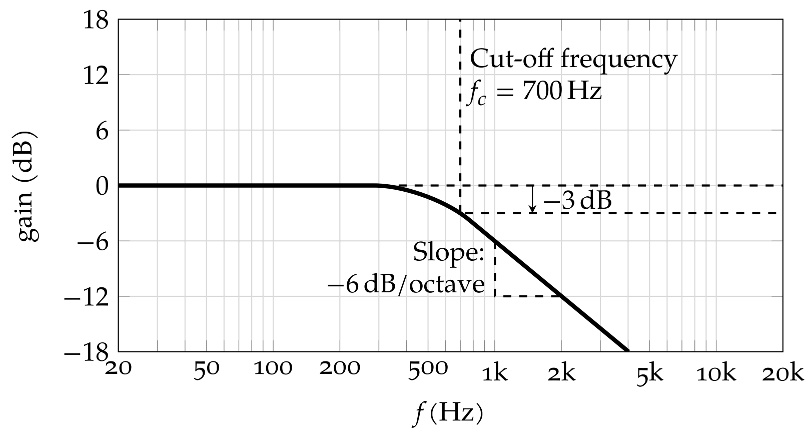

Figure 4. Frequency response of a high-cut (low-pass) filter

4.2 Shelving filters

- *Gain* $g > 0$ (boost) or $g < 0$ (cut) with regards to 0 dB response
- *Center frequency* f_C at $g/2$

4.3 Peaking filters

- *Gain* $g > 0$ (boost) or $g < 0$ (cut) with regards to 0 dB response
- Peaking filters with $g < 0$ are also called *notch filters*
- *Center frequency* f_C at g_{max}
- *Bandwidth* Δf defined by −3 dB (*not* −6 dB!) points
- But *quality* $Q = \frac{f_C}{\Delta f}$ relates better to sound perception (why?)

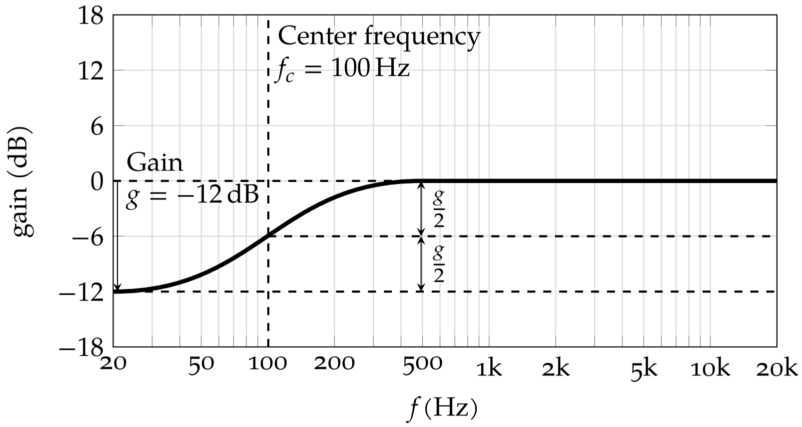

Figure 5. Frequency response of a low-frequency shelving filter

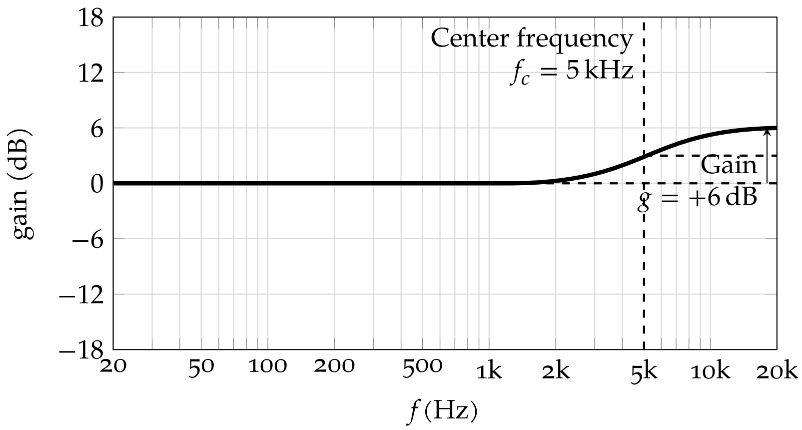

Figure 6. Frequency response of a high-frequency shelving filter

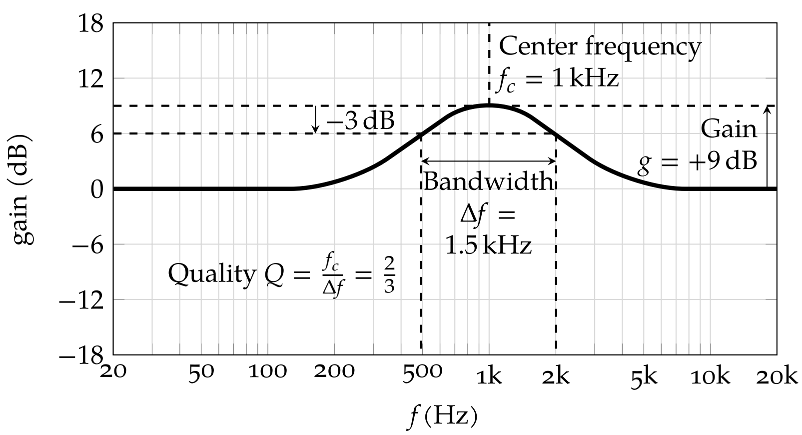

Figure 7. Frequency response of a peaking filter

5 Equalizers (EQs)

Combination of multiple filters, commonly:

- Shelving or cut filters (sometimes switchable) for LF and HF bands
- Peaking filters for variable number of *mid bands* (often 1 or 2)

5.1 Typical applications

- Remove low-frequency rumble: low-cut filter
- Noise reduction: HF shelving filter
- Remove AC hum: notch filter at multiples of 60 Hz (US) or 50 Hz (EU)
- Reduce unpleasant resonances at specific pitch(es): notch filters
- Remove DC offset: steep low-cut at ca. 5 Hz
- Separate instruments across audible spectrum (e.g., reduce leakage)
- Add 'brilliance': HF shelving filter

5.2 Parametric EQs

- Controlled by parameters outlined in table 1
- Really first choice for EQing individual instruments!
- Recommended DAW plugins:
  - Reaper: ReaEQ (comes with Reaper)
  - Ardour: `x42-eq` (6 Band; mono & stereo versions) by Robin Gareus Installation on Debian/Ubuntu: `sudo apt-get install x42-plugins`

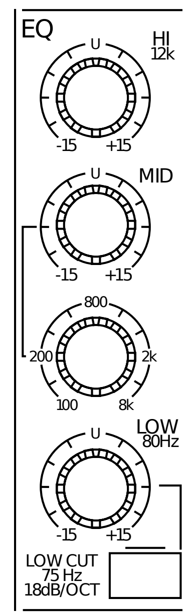

Figure 8. Parametric EQ in an input channel strip of a Mackie CR1604-VLZ mixing desk (© Loud Technologies Inc. With edits.

5.3 Graphic EQs

- Many frequency bands (say, 31), with one fader per band
- Initially more intuitive, but in many ways also less flexible – why?
  - ____
  - ____
  - ____
- Center frequencies of bands are spaced logarithmically, not linearly!
  - Idea: each band covers a constant frequency interval
  - Typical example: 10 octave bands ($1 : 2^1$) from 31.5 Hz to (ca.) 16 kHz
  - Or: 31 ⅓-octave bands ($1 : 2^{1/3}$) from 20 Hz to (ca.) 20 kHz
- Typically applied to a stereo mix (rather than an individual instrument)
- Often used to compensate room acoustics in live engineering
  - Suppress feedback & undesirable resonances
  - Frequently static settings (sometimes fixated with screws)

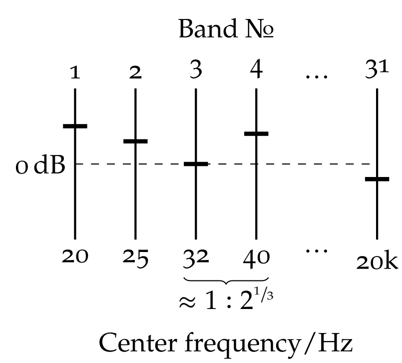

Figure 9. Principle of a graphic EQ with 31 ⅓-octave bands

5.4 EQing techniques & recommendations

- Rule of 👍: *Favor cutting over boosting!*
- Aim to retain peak level (might require adjusting overall output gain)
- EQing almost always requires a compromise:
  - A high-cut filter to remove tape noise might also affect piano sound
  - A low-cut filter to remove rumble might also affect kick drum 'oomph'
- EQing bass instruments traditionally challenging for novice engineers[3]
- Demo in Reaper: *Sweeping* the frequency range[4]
  1. Instantiate peak filter in a parametric EQ
  2. Set peak filter to high g and high Q (or small bandwidth)
  3. Slowly sweep f_c through frequency range
  4. When you have found the frequency, adjust g and Q to taste

[3] Senior (2011a, p. 176) has collected recommendations by different sound engineers on how to EQ bass instruments.

[4] The purpose of this technique is to locate frequencies in the spectrum that require adjustment by deliberately exaggerating them.

6 Preview ED2 assignment

References & further reading

Ariza, Christopher (2012). *21M.380 Music and Technology. Filters and Filter Parameters*. URL: http://ocw.mit.edu/courses/music-and-theater-arts/21m-380-music-and-technology-recording-techniques-and-audio-production-spring-2012/lecture-notes/MIT21M_380S12_lec07.pdf (visited on 09/30/2015).

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Senior, Mike (2011a). "Beyond EQ." In: *Mixing Secrets for the Small Studio*. 1st ed. Focal Press. Chap. 12, pp. 191–202. ISBN: 978-0240815800. MIT LIBRARY: 002092991. Electronic resource. Accompanying information and sound examples: http://www.cambridge-mt.com/ms-ch12.htm.

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