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

Dynamics & compression

Session 10 · Wednesday, October 12, 2016

1 Student presentation (PA1)

- [redacted]

2 Announcement: I want *you* for schlepping!

- Volunteers needed for Mon, 10/17 & Wed, 10/19 class meetings
- 2–3 volunteers at room [redacted], 10 minutes before start of class
- 2–3 volunteers after class (please approach me after class)

3 Review

3.1 ED1 assignment

- How to render to a meaningful output level
  - Watch level meters that appear at rendering
  - Must not hit red zone, otherwise you'll clip!
- Submission examples

3.2 Patchbays

- Half vs. full (single) normalled vs. open (denormalled) vs. parallel vs. fully isolated
- Rule of 🔊: *Don't patch under phantom power!*

3.3 Stereo recording techniques

- M/S recording technique
- Recording angle

4 Dynamic range

$$\Delta L = L_{max} - L_{min}$$

ΔL	dynamic range	dB
L_{max}	maximum signal level	dB
L_{min}	minimum signal level	dB

Equation 1. Dynamic range

- Difference between 'loudest' and 'softest' sound
- Corresponds (loosely) to musical dynamics (***p***, ***mf***, ***ff***, etc.)
- *Every* acoustic system has its dynamic range (e.g., mic, ear, room, etc.):
  - Symphony orchestra: ***ff*** vs. ***pp***
  - Human ear: absolute threshold of hearing vs. pain threshold
  - Digital audio converter: full-scale vs. 1 bit

Table 1. Dynamic range ΔL of different audio systems

Signal or system	ΔL/dB
Symphony orchestra	70
Pop music	6
Human ear	130
AKG C414 XLS	134
Digital audio (16 bit)	96
Digital audio (24 bit)	144

5 Dynamic range processors

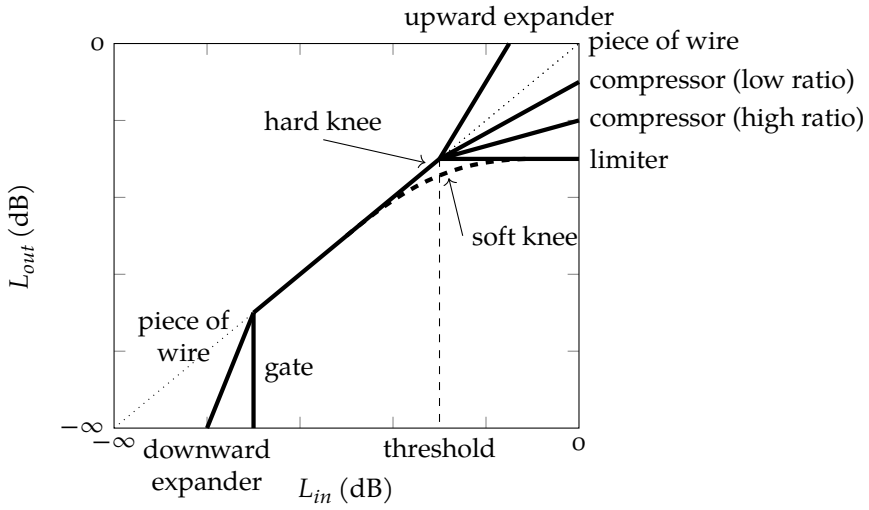

Figure 1. Transfer functions of different dynamic range processors

- Different processors exist to adjust the dynamic range
- Primarily defined by their *transfer function*:
  Output level L_{out} as a function of input level L_{in}
- Applications & motivations:
  - To match ΔL of recording and playback environments[1]
  - To make an individual track more 'mixable'
  - Ideally a tool to aid musical expression
  - Less ideally a tool to take all life out of a mix

[1] For example, it can be difficult to listen to a symphony orchestra recording with a dynamic range of 70 dB while driving on a freeway in a convertible, where your dynamic range is more likely in the single digits.

5.1 Compressor

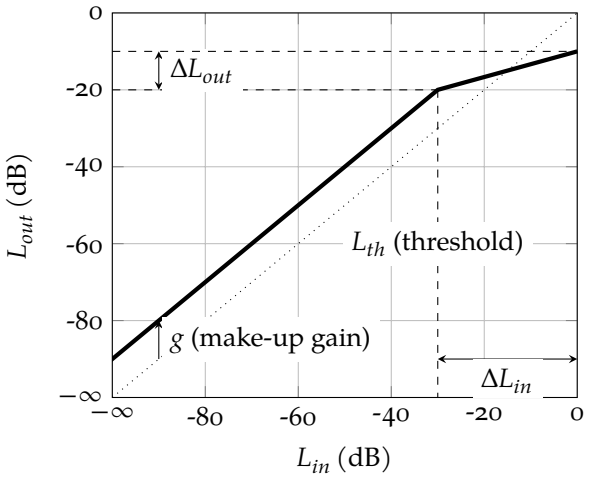

Figure 2. Transfer function of a compressor

- Reduces dynamic range, for example to:
  - Give drums more impact
  - Add 'fader stability' to vocal track
- Ubiquituous in pop & rock
  - Not unusual to see on *every* input (and perhaps output) channel
  - Widely (mis)used as a tool to win the *loudness war* (Katz 2014d)
- Much more conservatively used in classical music recordings

5.2 Limiter

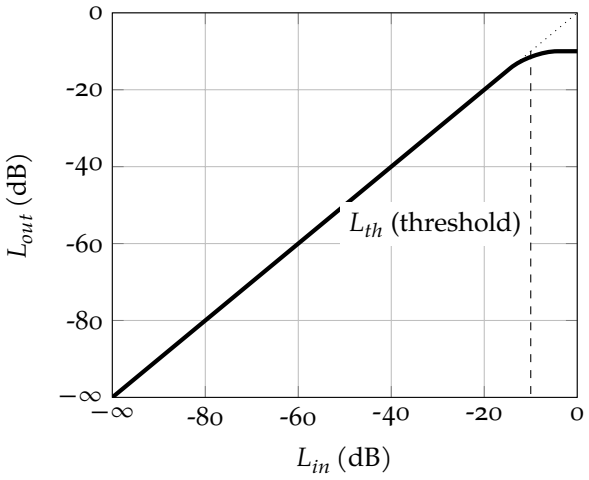

Figure 3. Transfer function of a limiter

- Limits dynamic range (no increase of L_{out} above L_{th})
- Application: prevent clipping (peak limiter: fast attack & sharp knee)

5.3 Expander

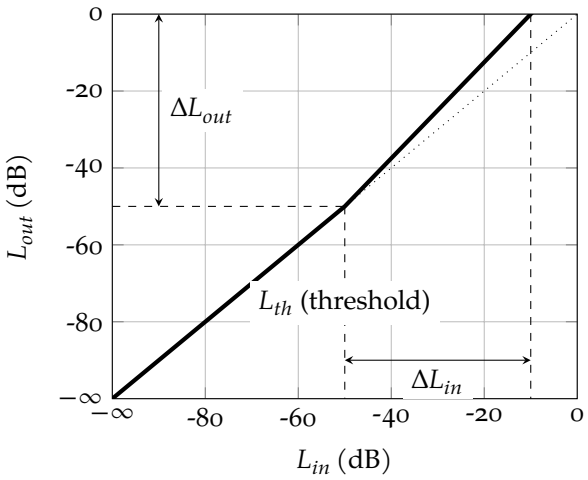

Figure 4. Transfer function of an upward expander

- Increases dynamic range
- Application: emphasize musical phrasing
- Upward vs. downward expanders

5.4 Gate

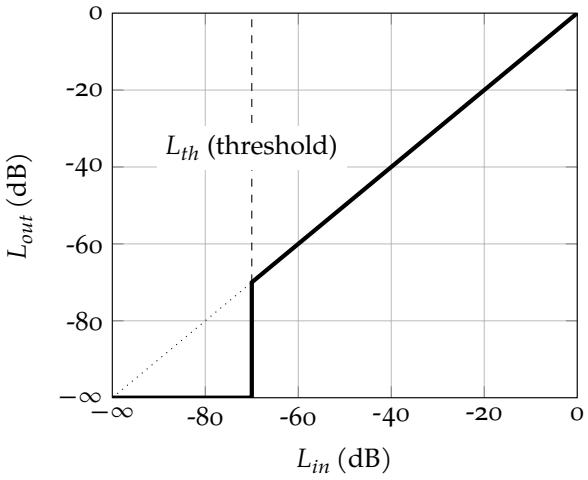

Figure 5. Transfer function of a gate

- Mute signal below threshold to eliminate background noise
- Works particularly well with percussive sounds (drums)

6 Control parameters

6.1 Threshold, ratio, knee, make-up gain

Control parameters that can be determined from the transfer function:

- *Threshold* L_{th} above (or below) which dynamic range is affected
- *Ratio* R at which input signal is compressed or expanded
- *Knee*: hard vs. soft; typically specified in dB
- *Make-up gain* g: e.g., to increase overall output level after compression

TABLE 2. Parameters of dynamic range processors

Parameter	Symbol	Unit
Threshold	L_{th}	dB
Ratio	R	1
Knee	—	dB
Make-up gain	g	dB
Attack time	T_a	ms
Release time	T_r	ms
Release delay	T_d	ms

$$R = \frac{\Delta L_{in}}{\Delta L_{out}}$$

R	ratio	1
ΔL_{in}	input level change	dB
ΔL_{out}	resulting output level change	dB

EQUATION 2. Ratio R of a dynamic range processor

TABLE 3. Ratio R of dynamic range processors

Processor	R	Typical values
Compressor	> 1	2:1, 3:1, 4:1, etc.
Limiter	$\to \infty$	
Expander	< 1	1:2, 1:3, 1:4, etc.
Gate	$\to 0$	

6.2 Attack time, release time, release delay

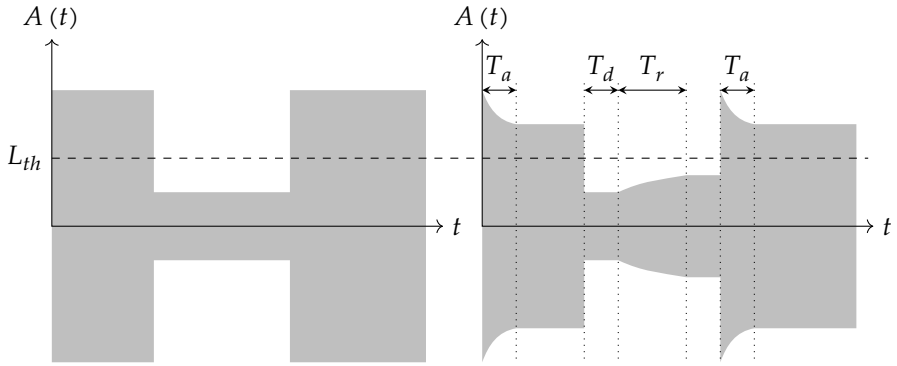

FIGURE 6. Input (left) and output (right) of a compressor with attack time T_a, release time T_r, and release delay T_d all $\neq 0$ (after Katz 2014b, fig. C)

- But the sound of a dynamic range processor is also significantly determined by its *temporal* behavior:
  - Attack time T_a in response to input level change $L_{in} > L_{th}$
  - Release time T_r in response to input level change $L_{in} < L_{th}$
  - Release delay T_d (less common)
- These parameters can*not* be determined from the transfer function!

7 Compression techniques

7.1 General compression recipe

- First convince yourself (by ear & eye) that compressor does *something*!
- Then set threshold and finally adjust other settings to taste
- Katz (2014b, p. 93) suggests to:
  1. Use a high ratio (e.g., 4:1) and fast release time (e.g., 100 ms)
  2. Find useful threshold around the music's 'action point'
  3. Reduce ratio (e.g., to 1.2:1)
  4. Increase release time (e.g., to 250 ms)
  5. Listen and fine-tune attack time, release time, and ratio

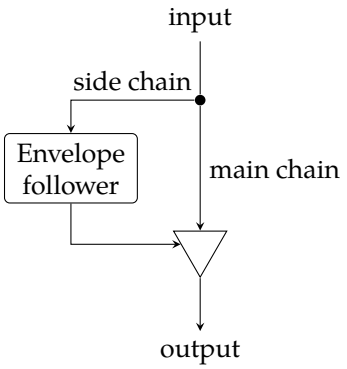

Figure 7. Side chain in a feed-forward compressor

7.2 Side chain manipulation

- A compressor's *side chain* includes the *envelope follower* that measures the level of the input signal (cf., figure 7).
- Several interesting ways in which side chain can be manipulated:
  - Feed with other instrument (aux in; e.g., bass 'makes room' for kick)
  - Side chain EQing (cf., figure 8): de-essing; prevent kick drum from 'bringing down' rest of band; etc.
  - Stereo compression: link side chains of L and R inputs
  - Lookahead function: delay main against side chain (peak limiting)

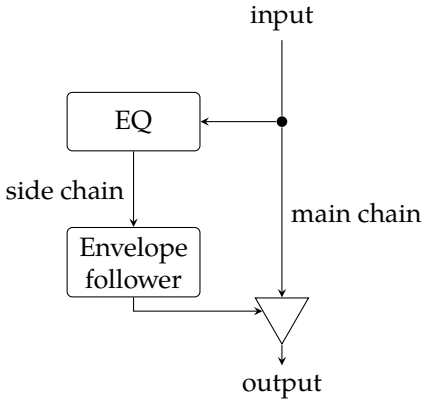

Figure 8. Side-chain EQing (e.g., de-esser)

7.3 Multiband compression

- Idea: Different transfer functions for different frequency bands
- Blurs border between compression and EQing
- Applications:
  - De-essing (ca. 2 kHz to 10 kHz; cf., Katz 2014b, p. 97)
  - Selective compression of individual instruments *in a completed mix*

7.4 Parallel compression

- Idea: Compression as a mix-in effect (cf., figure 9)
- Motivation: Compress while preserving *transients* (rapid signal changes)
- Recipe (Katz 2014c, p. 103):
  - Threshold: −50 dB
  - Ratio: $^{2.5}/_{1}$
  - Attack time: very short
  - Release time: 250 ms to 350 ms

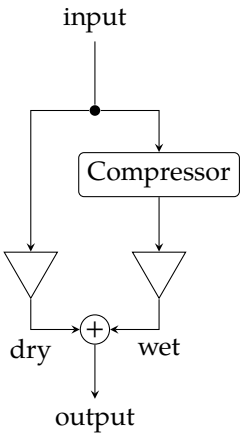

Figure 9. Parallel compression

8 Reaper demos

8.1 How to set up a gate in Reaper

1. Add new track with snare drum recording
2. Add gate plugin to track: FX » VST: ReGate (Cockos)
3. Set parameters

8.2 How to set up a compressor in Reaper

1. Add new track with vocal recording
2. Add compressor plugin to track: FX » VST: ReaComp (Cockos)
3. Set parameters

9 Preview ED3 assignment

- Use different dynamic range processors to solve specific tasks
- Also includes some EQing as a review

References & further reading

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