FX Basics

Dynamics Effects

STOMPBOX DESIGN WORKSHOP

Esteban Maestre

CCRMA - Stanford University

August 2013

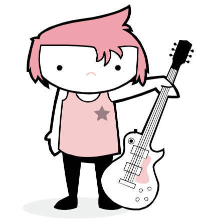
FX Basics: Dynamics Effects

Dynamics effects were the **earliest effects** to be introduced by guitarists.

The simple idea behind dynamics effects is to **amplify or attenuate the amplitude of the electrical signal** coming out from the pickup or microphone.

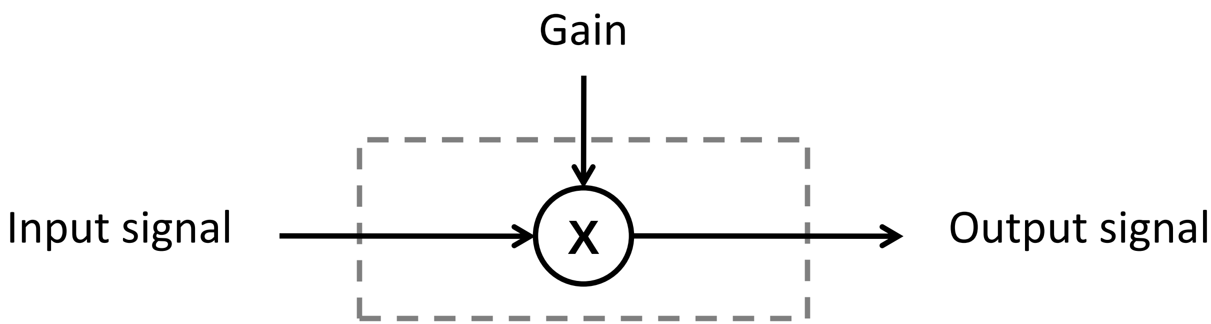
They first appeared in the 1940s as simple on/off switch boards, evolving to volume pedals in the 1950s.

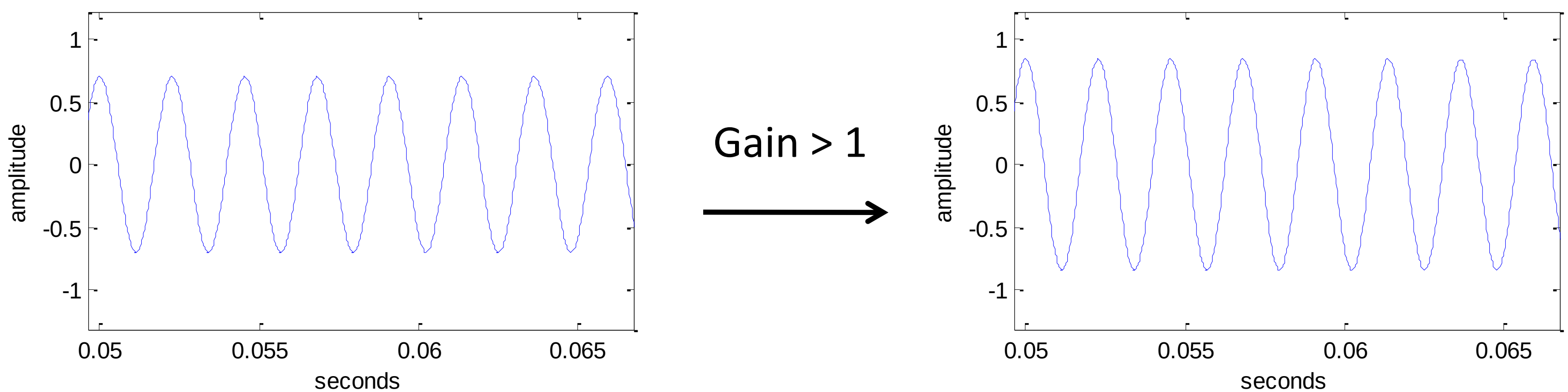
Ex: volume pedal, boost, tremolo,
noise gate, dynamic range compressor

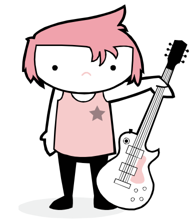


Gain control

Achieved by means of a simple multiplication.



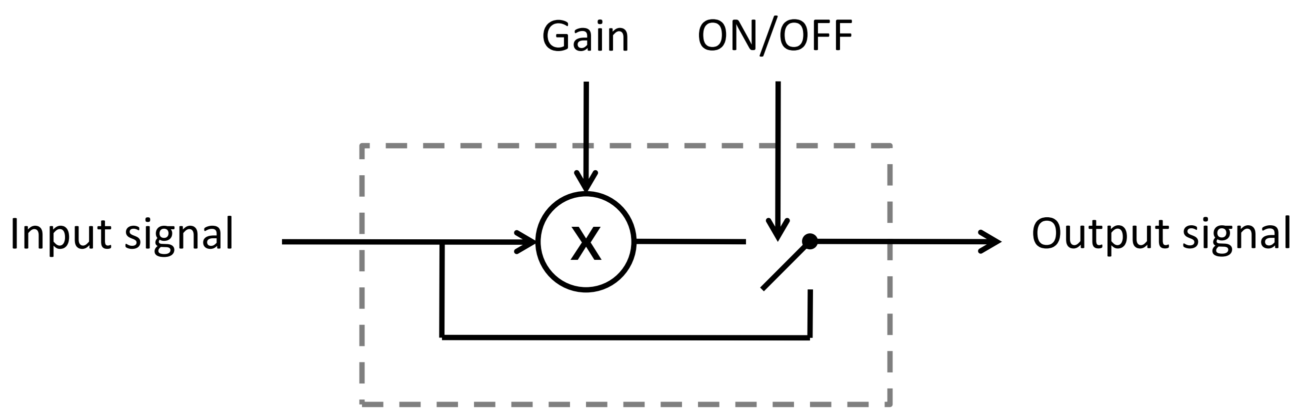


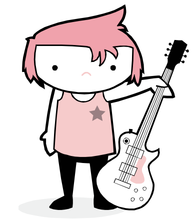


Volume Boost

Generally used for *boosting* volume during solos and/or preventing signal loss in long *effect chains*.

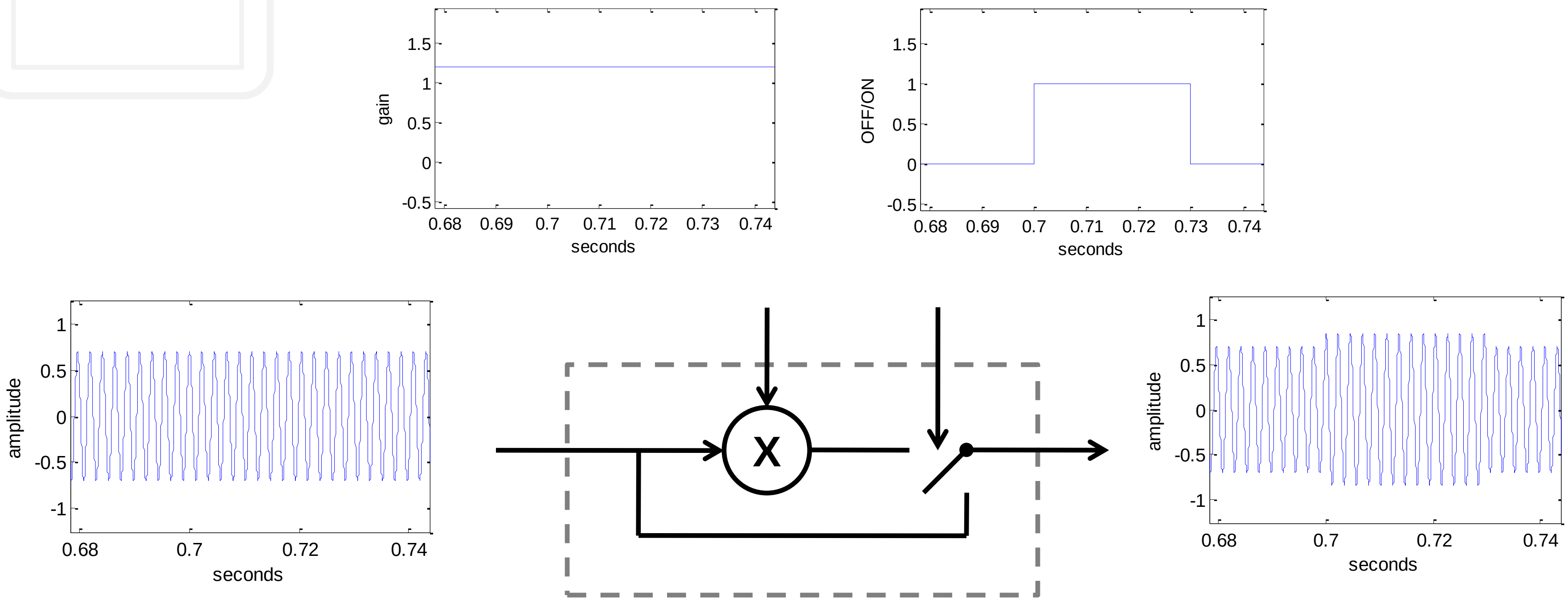
Ex: when switching from rhythm guitar to lead guitar, a guitarist may use a clean boost to increase the volume of his or her solo.



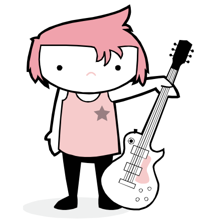


Volume Boost (ii)

FX Basics:
Dynamics Effects



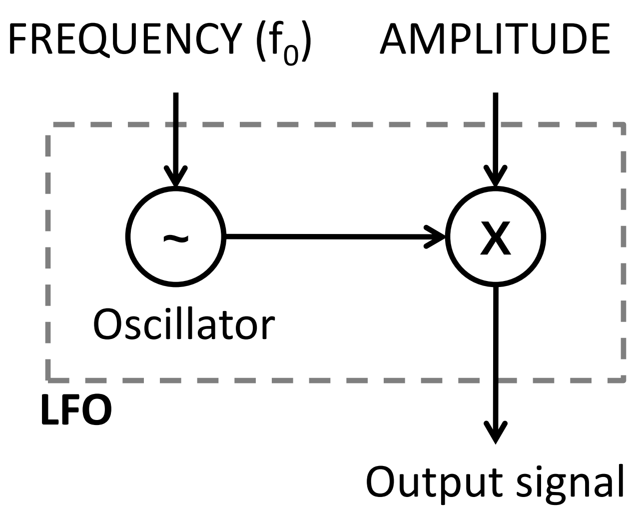
pd~ 00_stomp_dynamics_1.pd

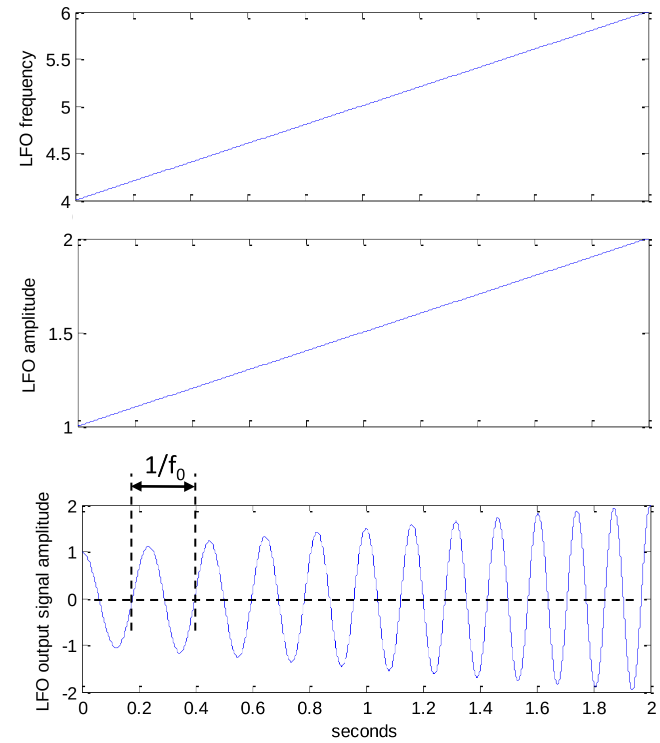


Tremolo

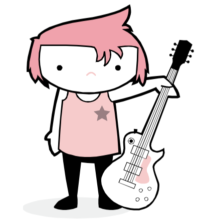
Produces a slight, rapid oscillation of the signal amplitude; not to be confused with *tremolo bar* (pitch oscillation).

Based on the use of a
Low Frequency Oscillator (**LFO**):





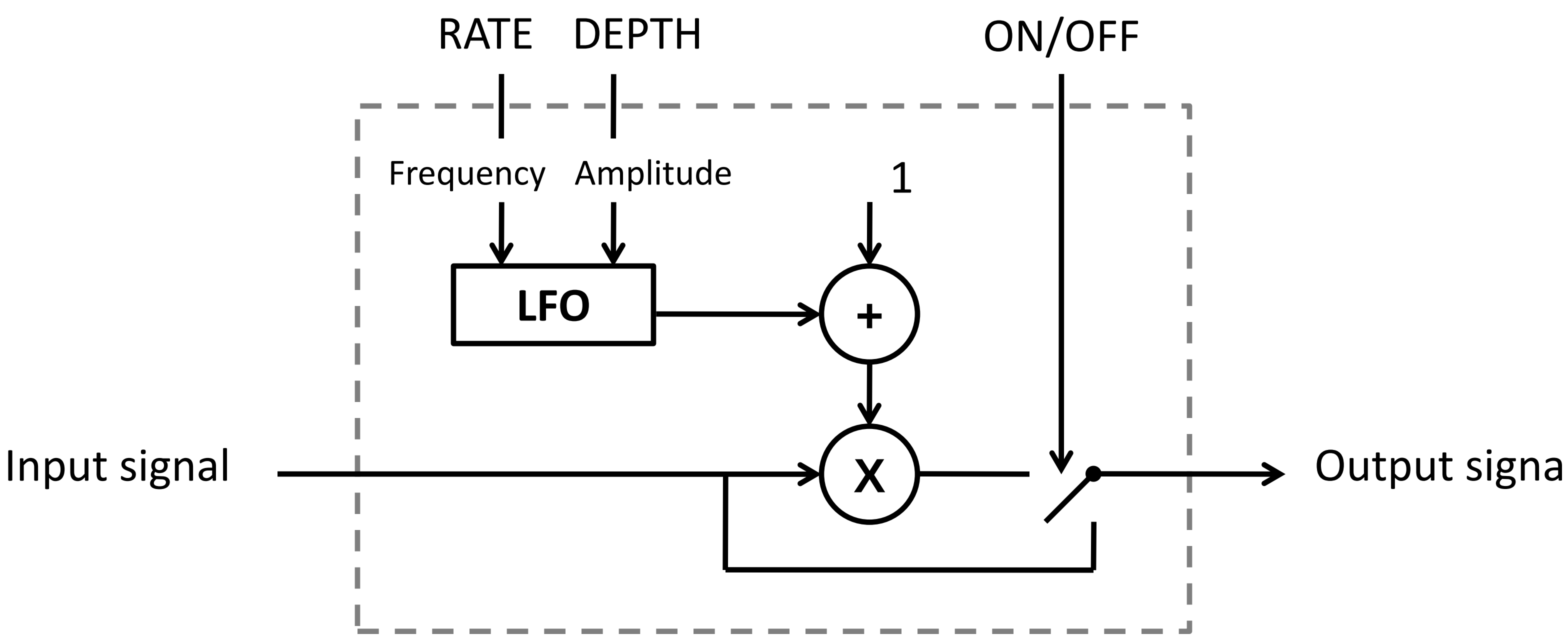
Tremolo (ii)

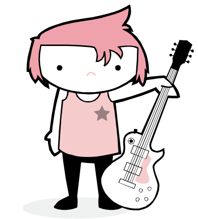


Typically, two controls are offered:

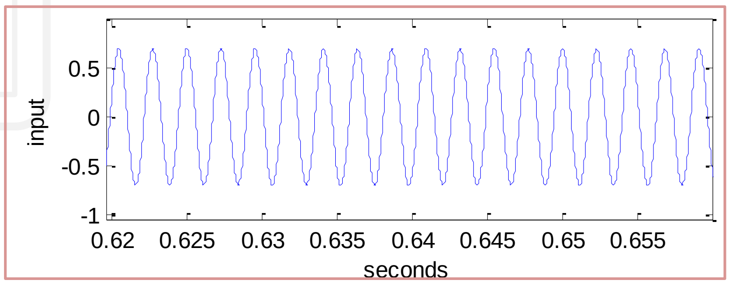
RATE: Sets the frequency of the volume oscillation

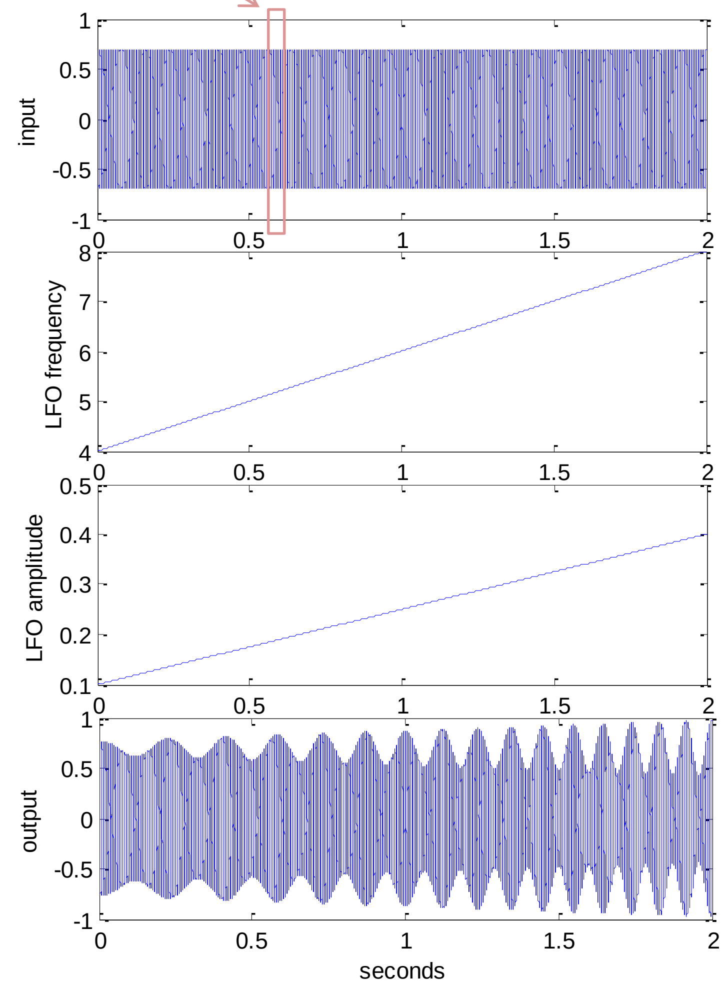
DEPTH: Sets the amplitude of the volume oscillation

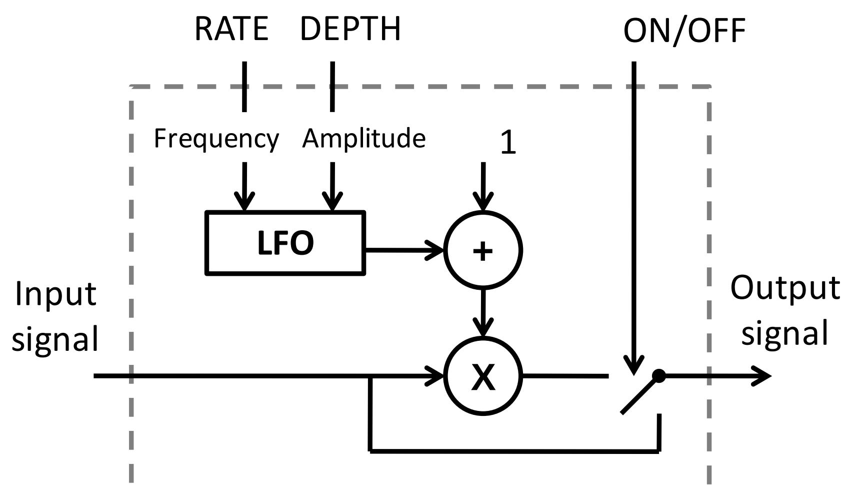




Tremolo (iii)





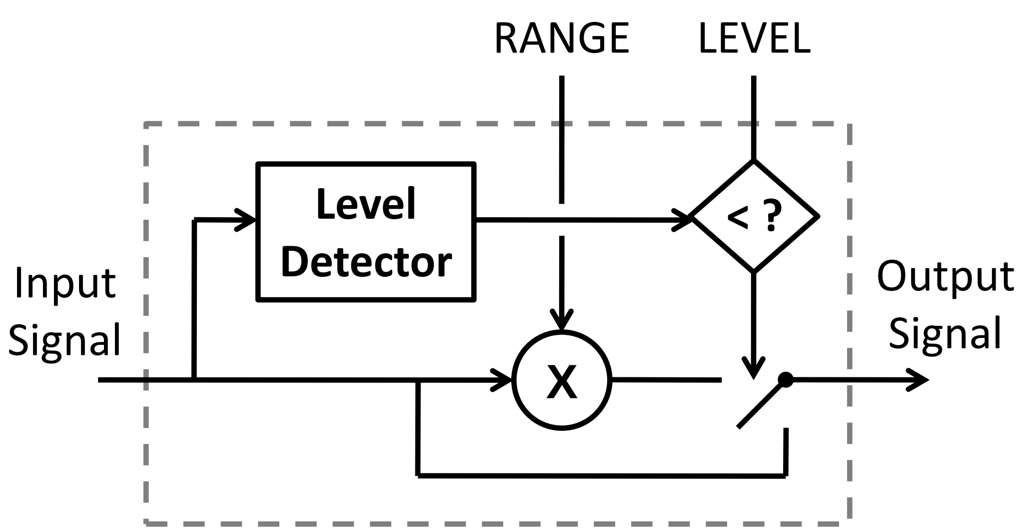


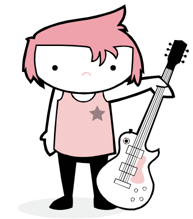
pd~ 01_stomp_dynamics_2.pd

Noise gate

Attenuates signal when its level falls below a given threshold. Both the attenuation and threshold are usually available as user controls (resp. RANGE and LEVEL).

Ex: avoid unwanted noise floor when there is no signal coming from the instrument



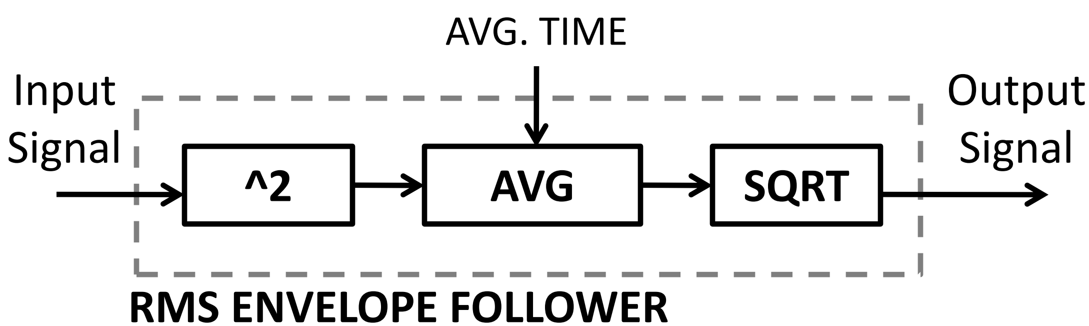


Noise gate (ii)

LEVEL DETECTOR (Envelope Follower):

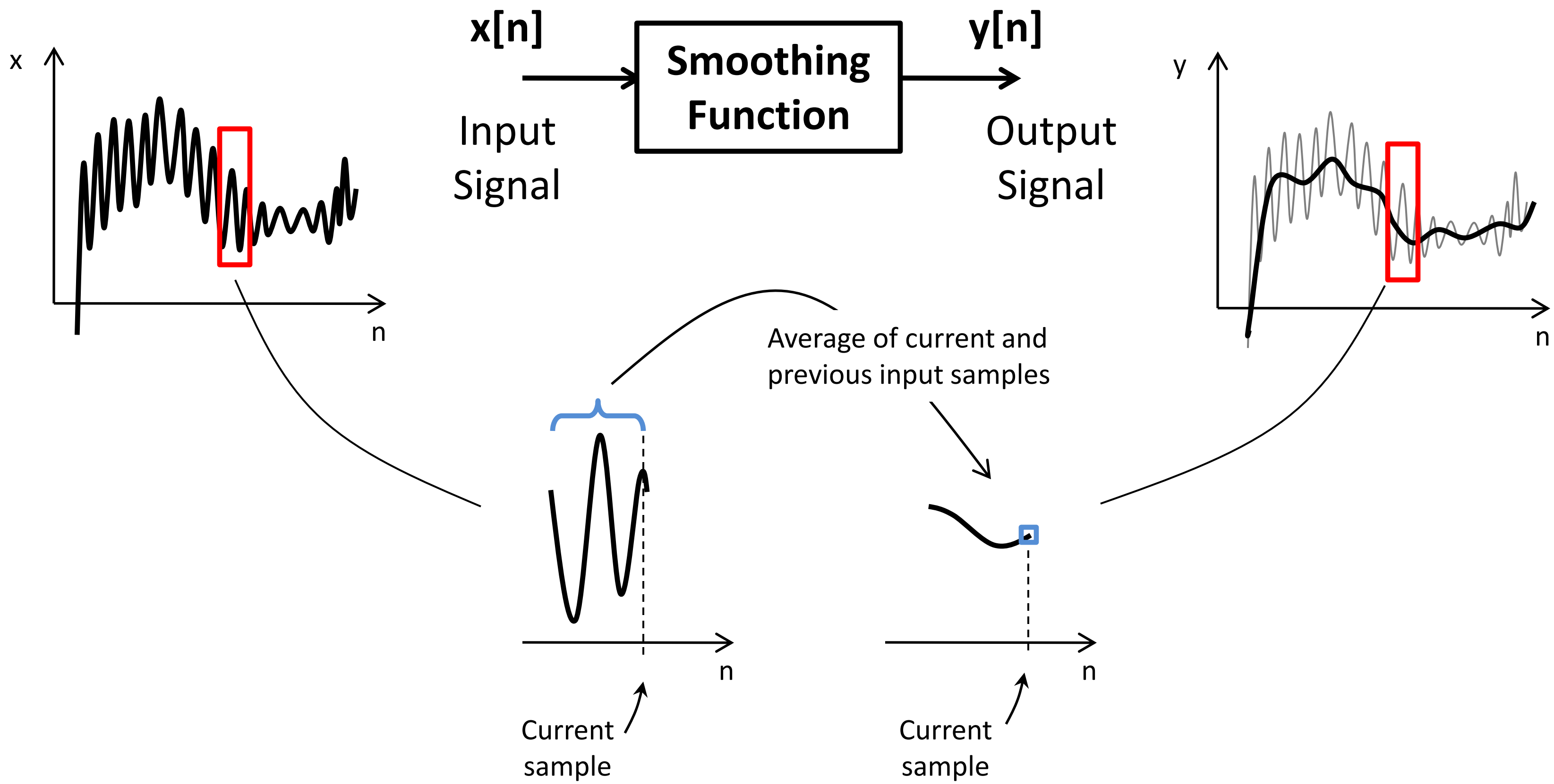
Often implemented as Root Mean Square (RMS) meter. RMS amplitude provides a measure of effective (short-time averaged) signal intensity.

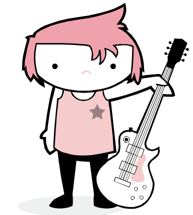
'Averaging time' sets the responsiveness of the meter.



TIME AVERAGE

Acts as a smoothing function:





TIME AVERAGE:

$$y[n] = (1/M) \cdot (x[n] + x[n-1] + \ldots + x[n-M+1] + x[n-M])$$

Obtain M from 'averaging time' : $M = avgTime \cdot f_s$

SMOOTHING WITH RECURSIVE EQUATION:

Find coefficients **a** and **b** so that equation

$$y[n] = b_0 \cdot x[n] + b_1 \cdot x[n-1] + \ldots + b_N \cdot x[n-N]$$ ⟵ current and previous input samples

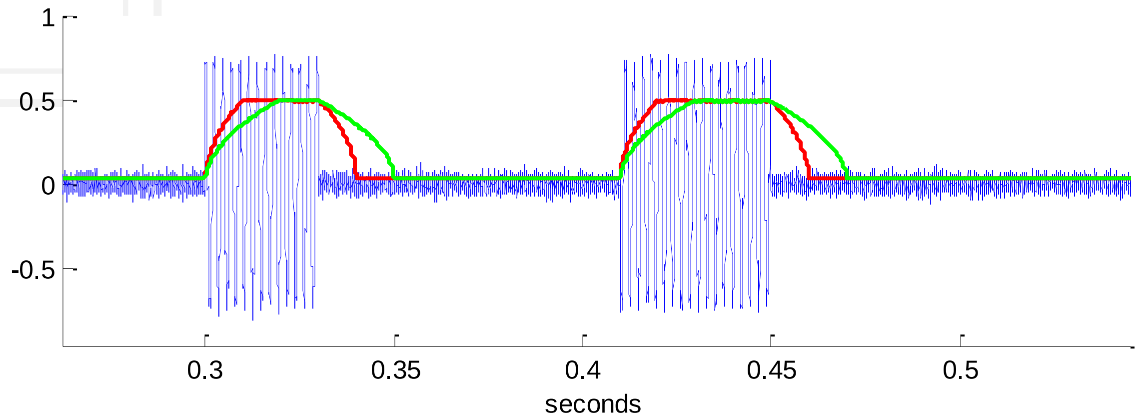
$$- a_1 \cdot y[n-1] - \ldots - a_N \cdot y[n-N]$$ ⟵ previous output samples

results into a smoothing function.

…digital implementation of a Low Pass (**LP**) filter.

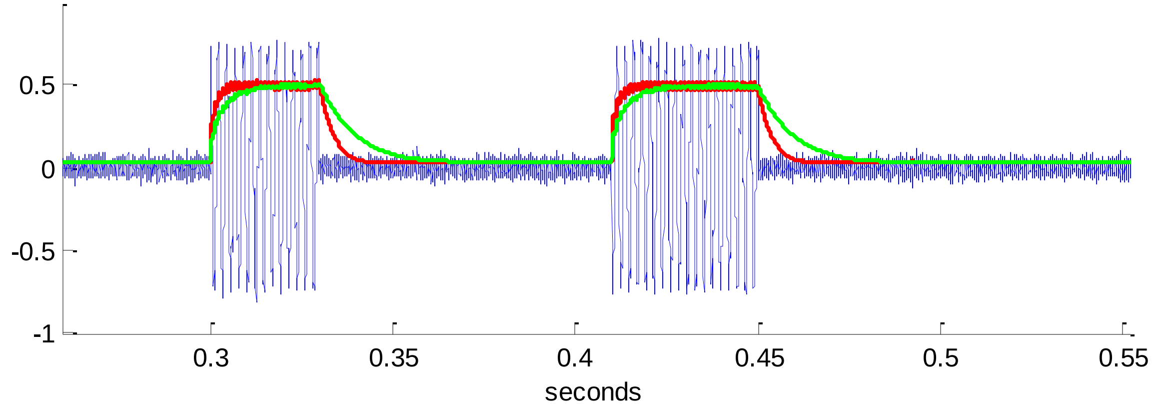
RMS Envelope…

With TIME AVERAGE:



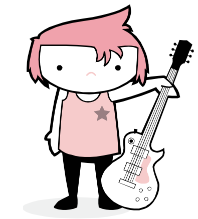
Averaging using **441 and 882 previous samples** respectively (M=441; M=882)

With Smoothing Low-Pass Filter (RECURSIVE):



Both filters only using **1 previous sample** (N=1) !!

FX Basics:
Dynamics Effects



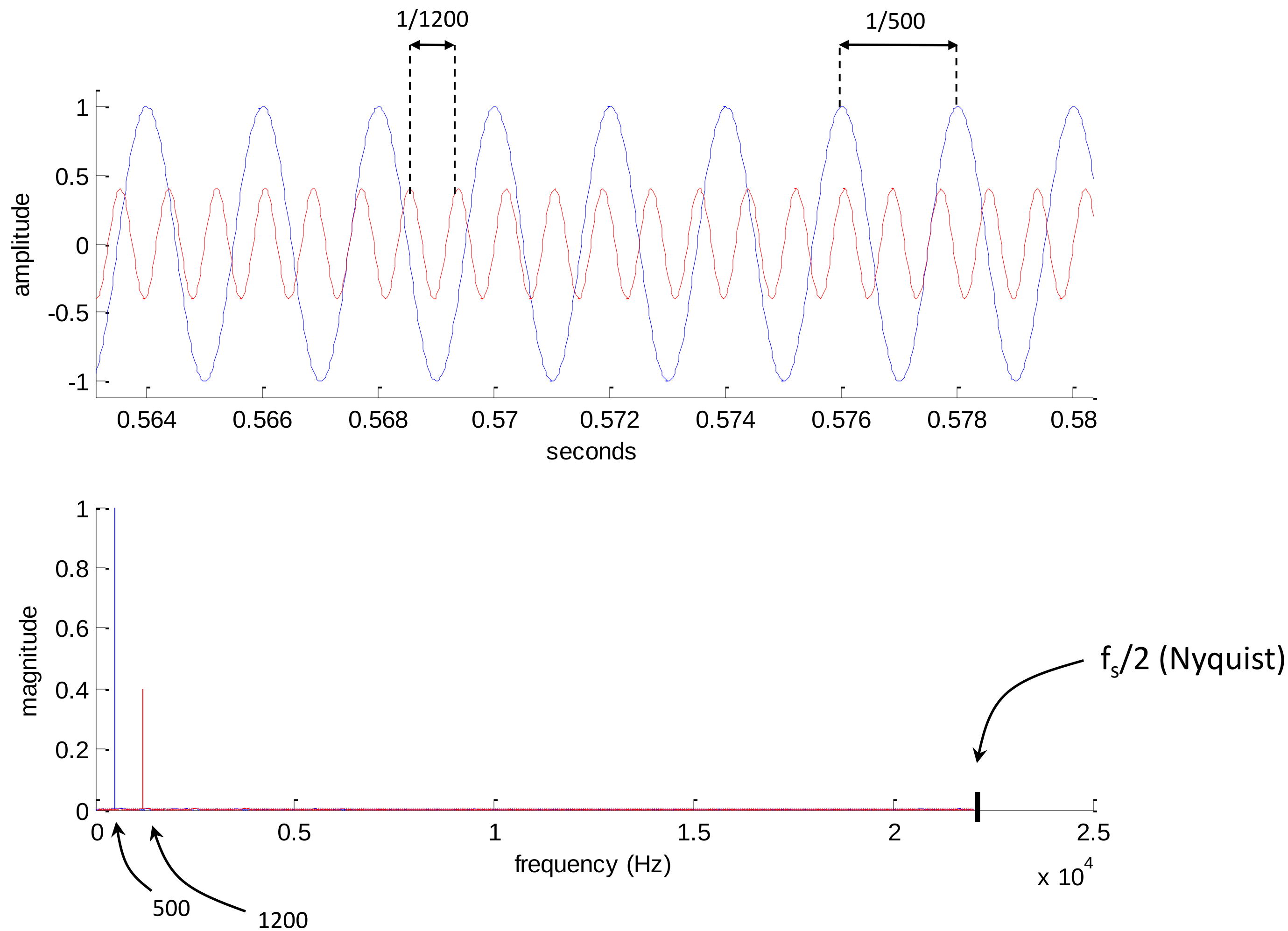
TIME DOMAIN

/

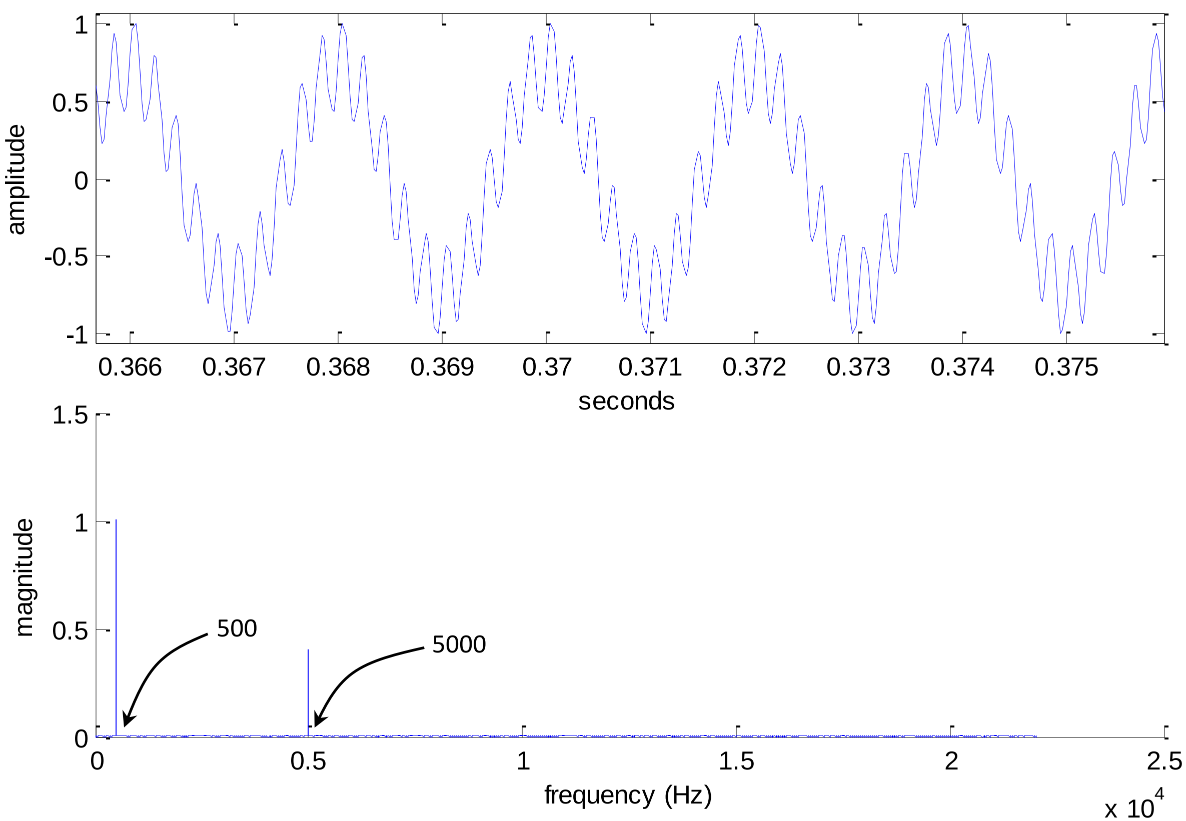
Fourier Transform

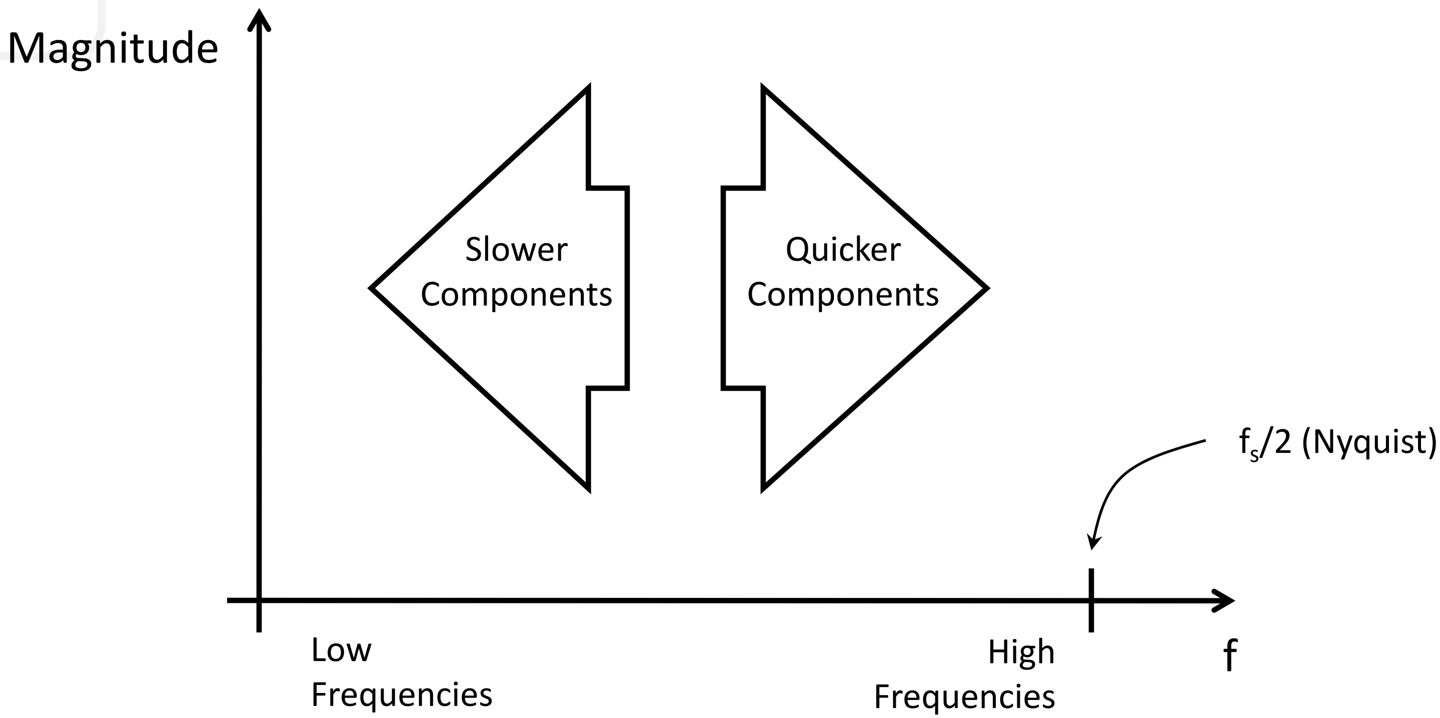
↓

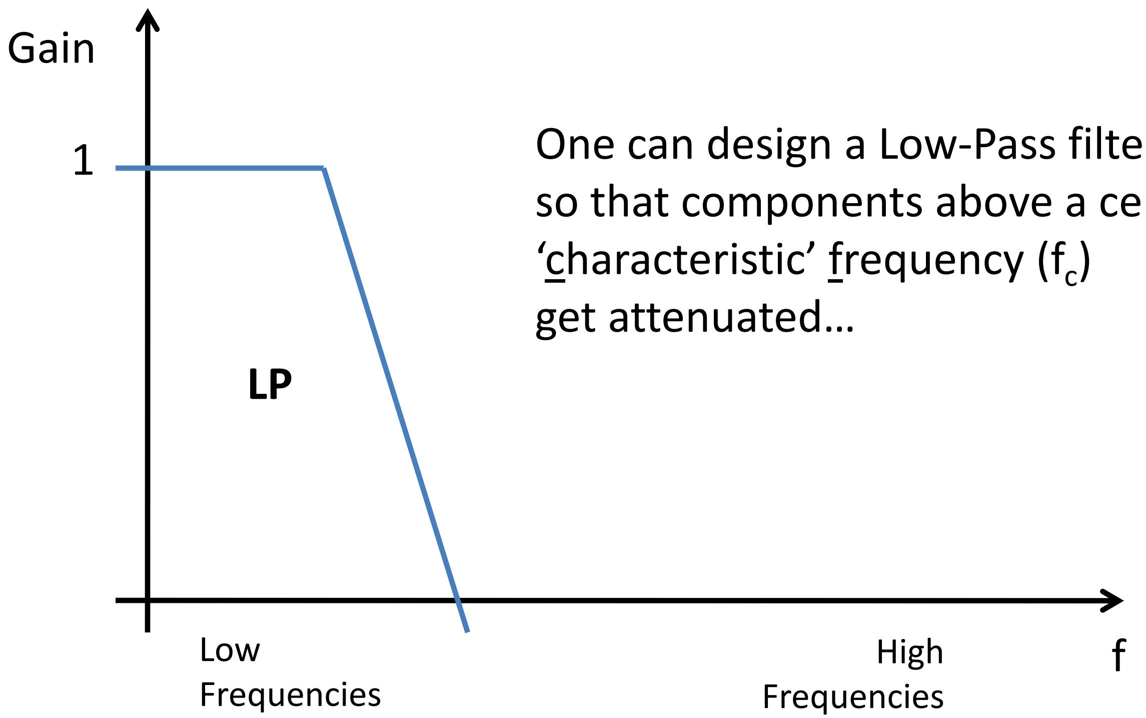
FREQUENCY DOMAIN



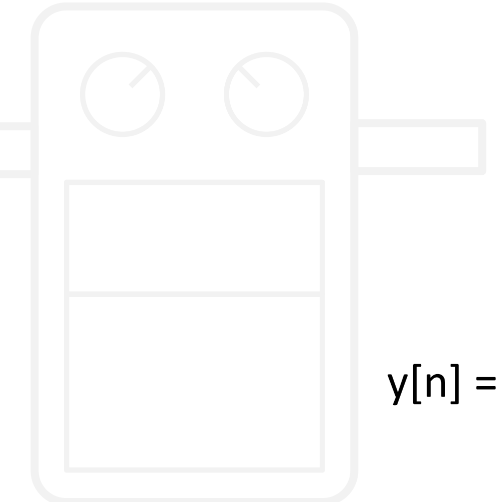
$$x(t) = 1.0 \cdot \sin(2 \cdot \pi \cdot 500 \cdot t) + 0.4 \cdot \sin(2 \cdot \pi \cdot 5000 \cdot t)$$



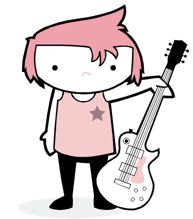

Magnitude
Slower Components
Quicker Components
f_s/2 (Nyquist)
Low Frequencies
High Frequencies
f



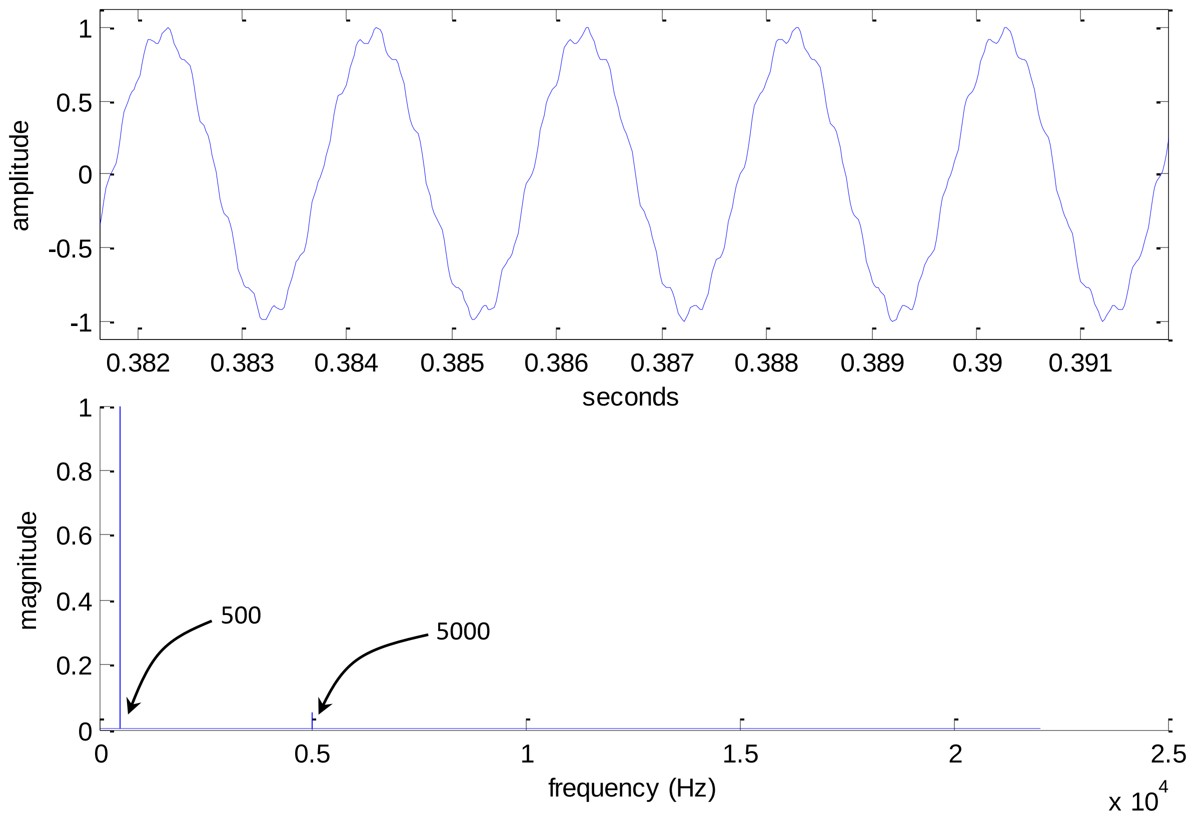
One can design a Low-Pass filter so that components above a certain 'characteristic' frequency (f_c) get attenuated...



FX Basics:
Dynamics Effects

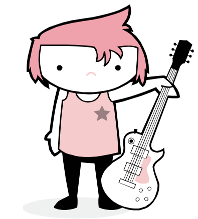


$$y[n] = \mathbf{0.0344} \cdot x[n] + \mathbf{0.0344} \cdot x[n-1] + \mathbf{0.9312} \cdot y[n-1]$$



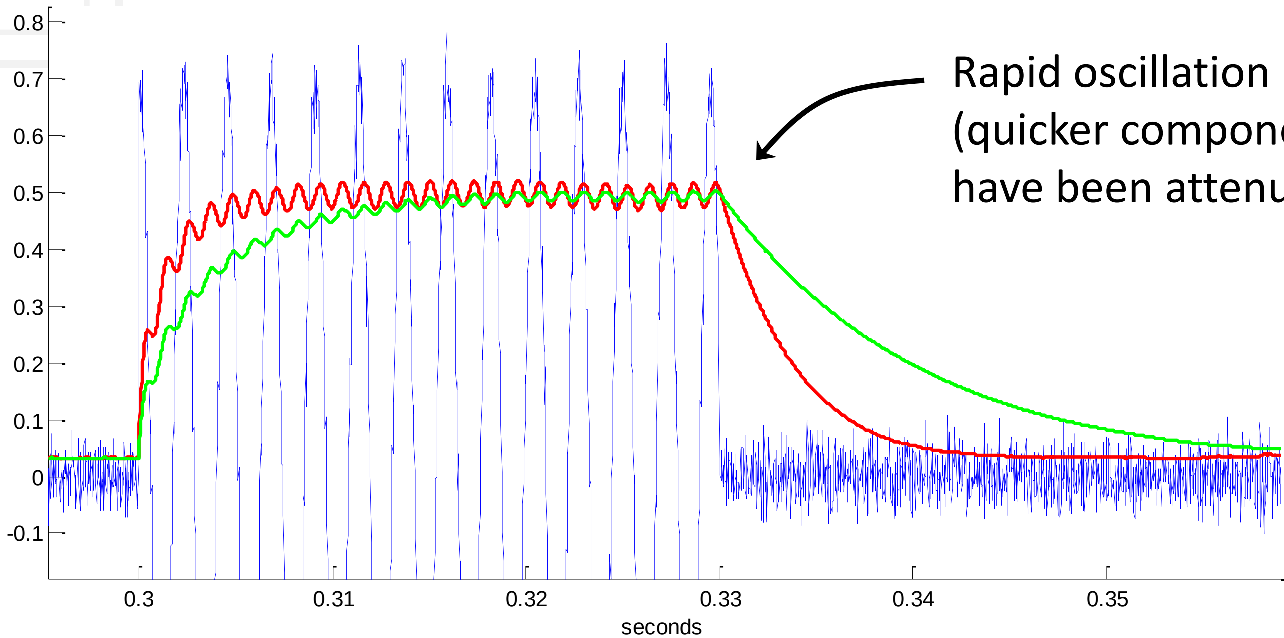
How to 'design' the coefficients? (e.g. how many coefficients? which values?)

Basics of **DIGITAL FILTERS** **(to come…)**

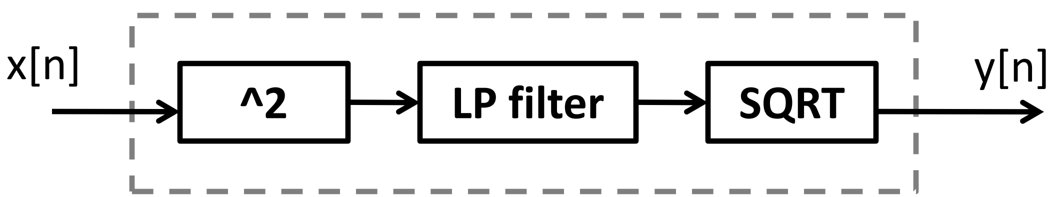


Noise gate (iii)

RMS Envelope Follower



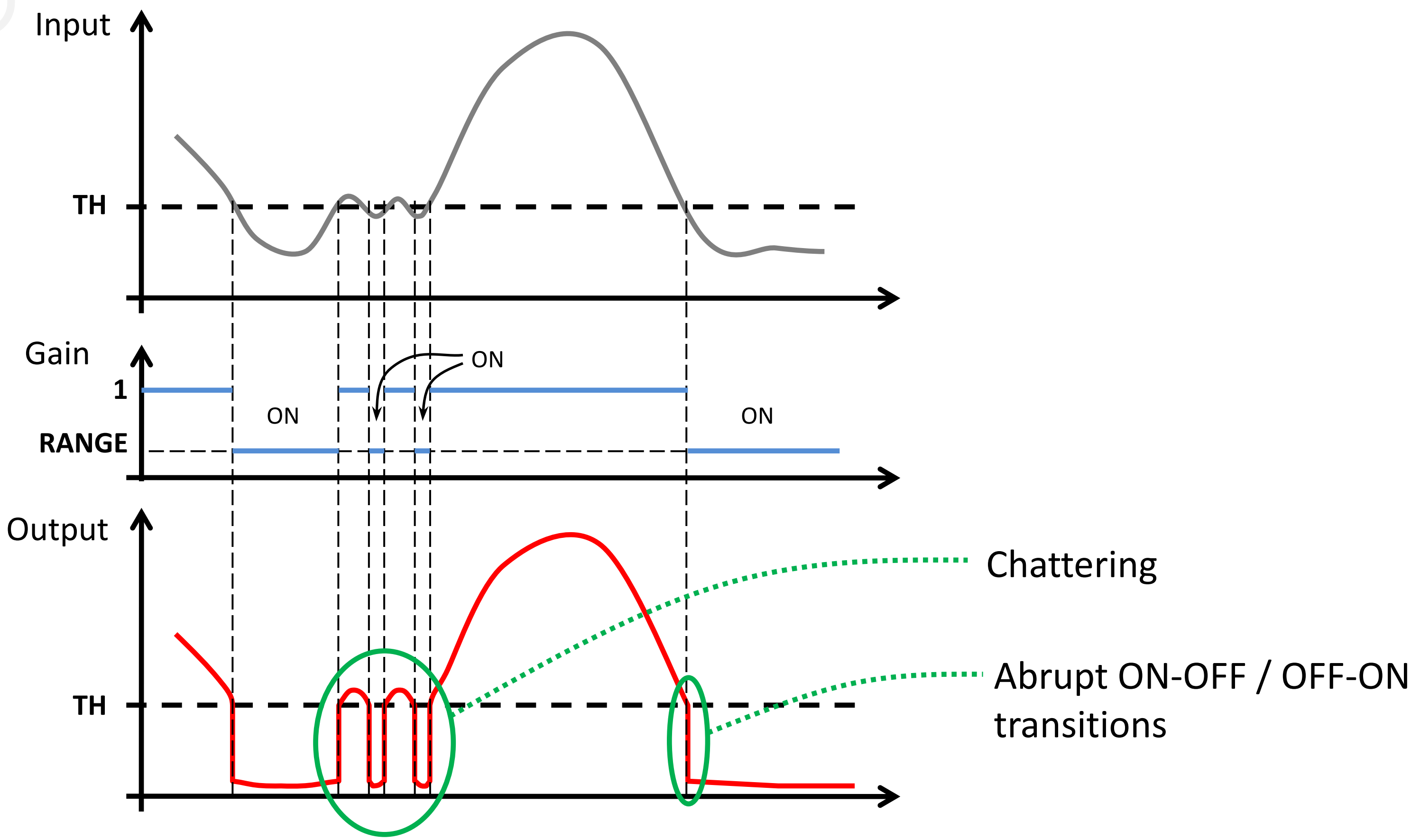
Rapid oscillation (quicker components) have been attenuated

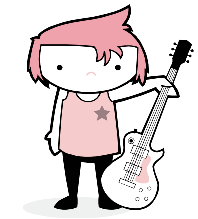


RMS ENVELOPE FOLLOWER

Noise gate (iv)

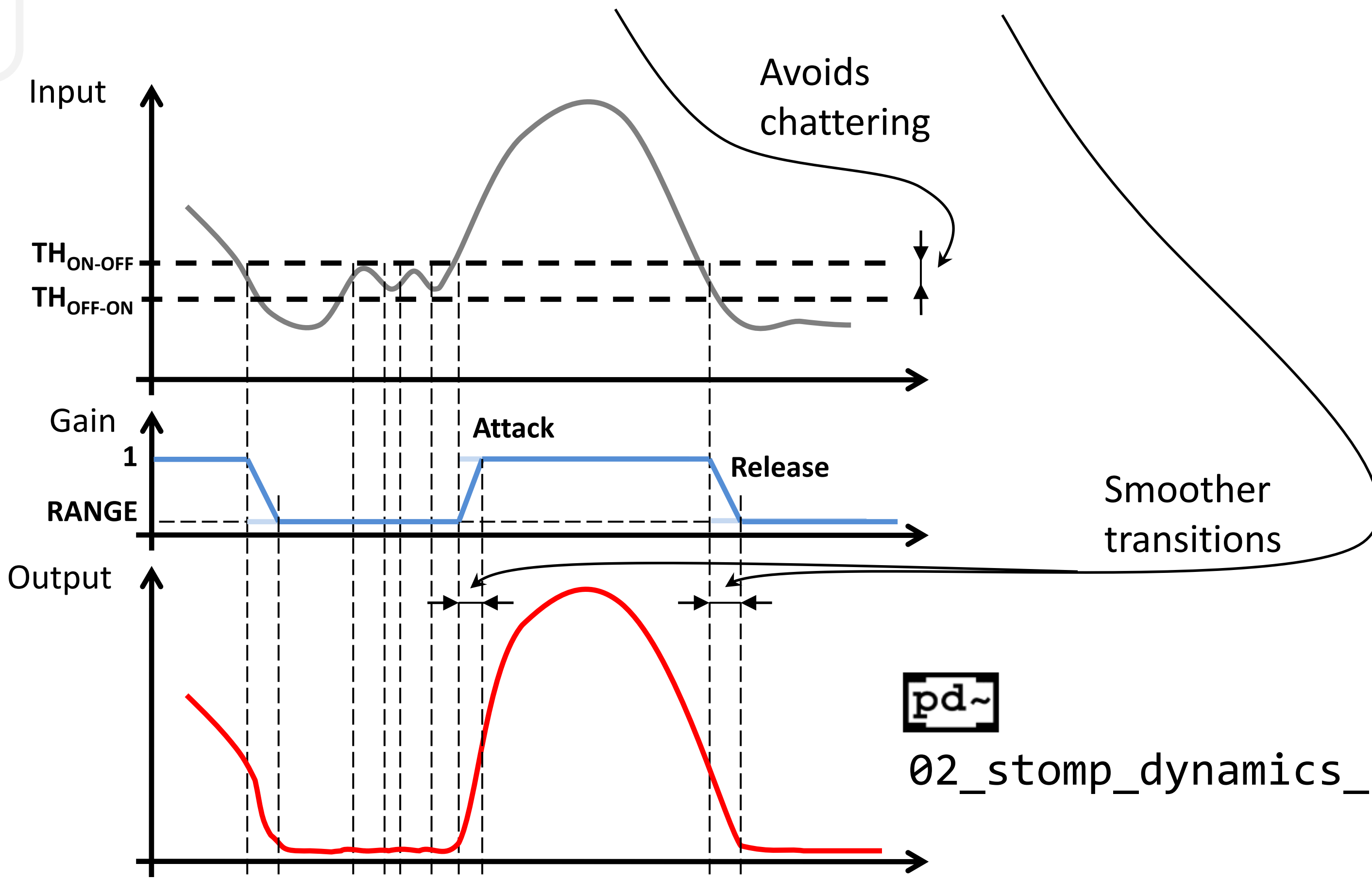
Example of basic operation





Noise gate (v)

Noise gates often include **HYSTERESIS** and **ATTACK/RELEASE** times



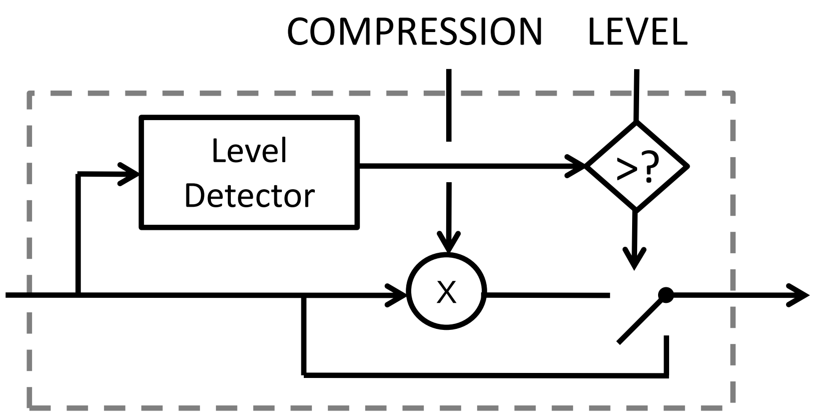
pd~

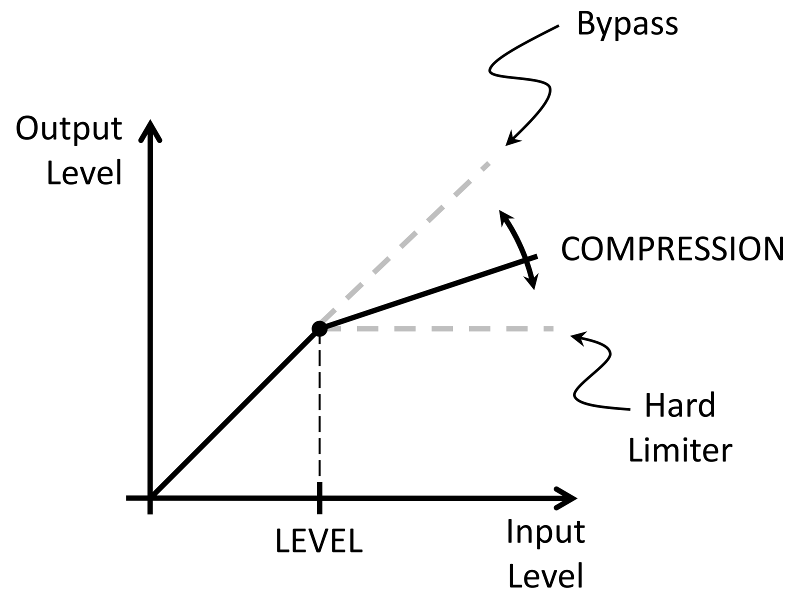
`02_stomp_dynamics_3.pd`

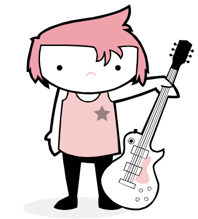
Dynamic Range Compressor

Attenuates the signal when its level its higher than a certain threshold. Both the amount of attenuation and the threshold are the most typical user controls (resp. COMPRESSION/RATIO and LEVEL).

Ex: reduce intensity differences, soften the amplitude of very loud attacks

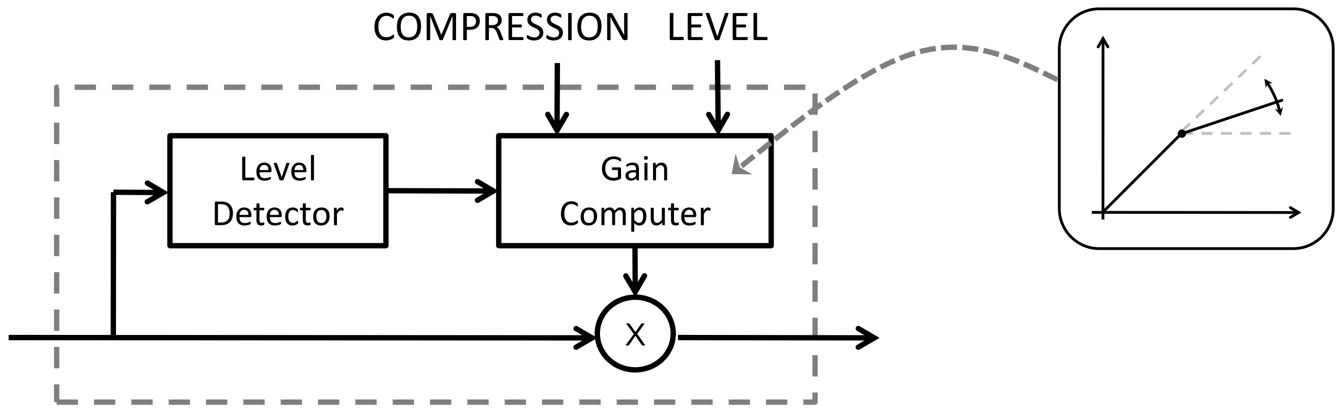




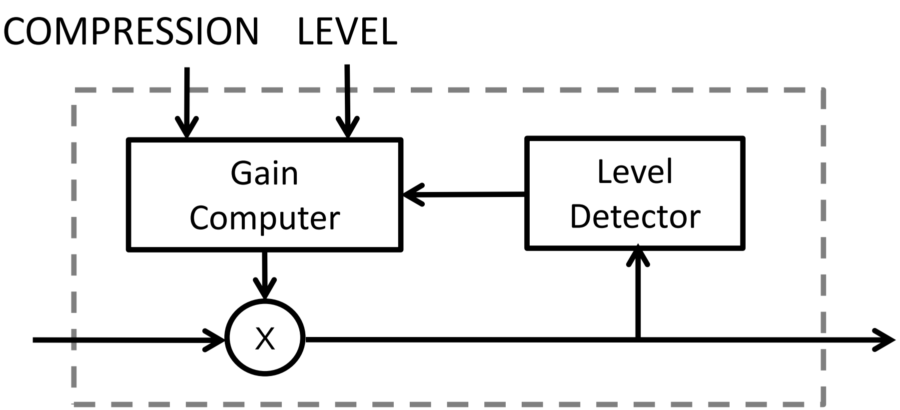


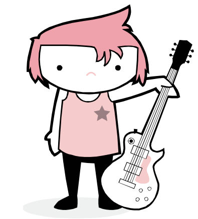
Dynamic Range Compressor (ii)

FEED-FORWARD
basic structure



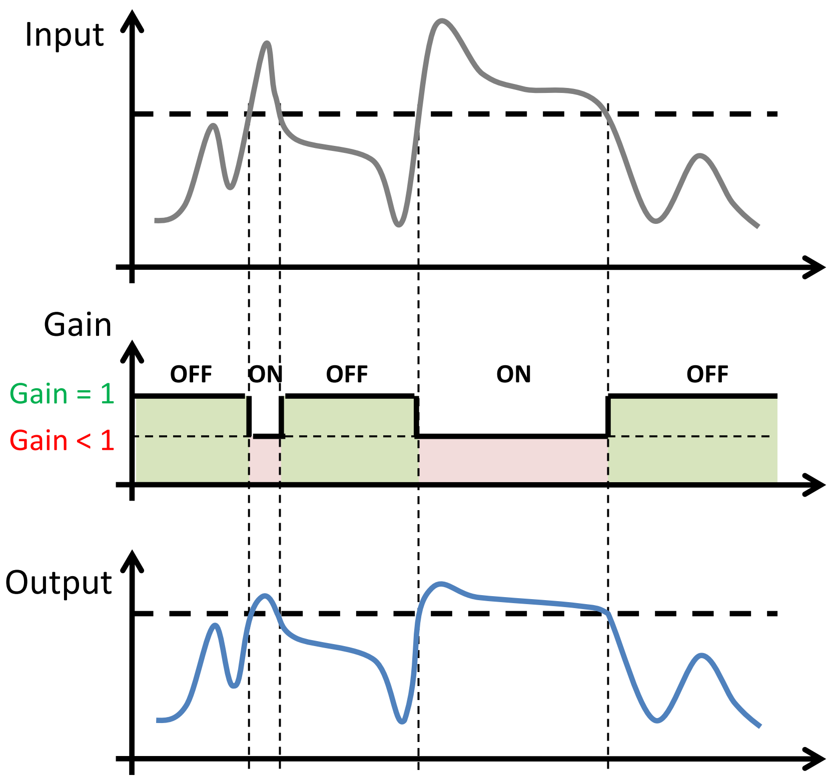
FEED-BACK
basic structure

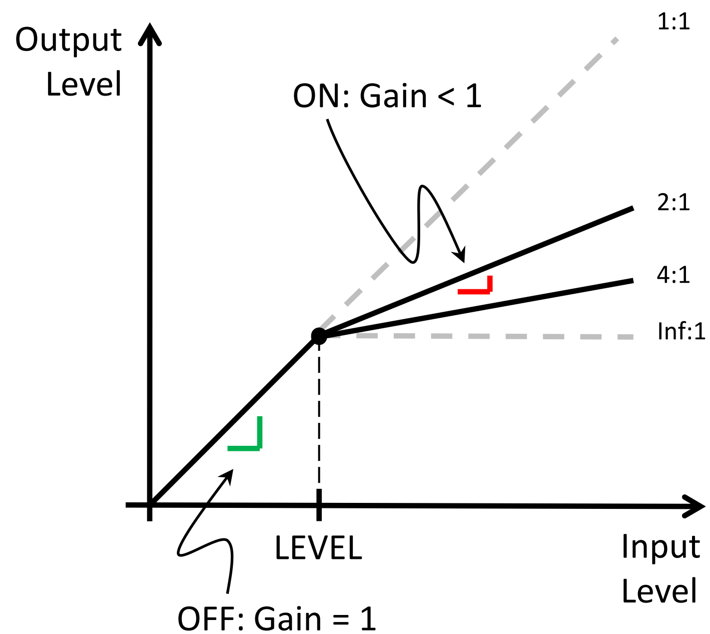


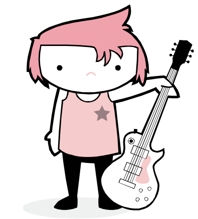


Dynamic Range Compressor (iii)

Example of basic operation



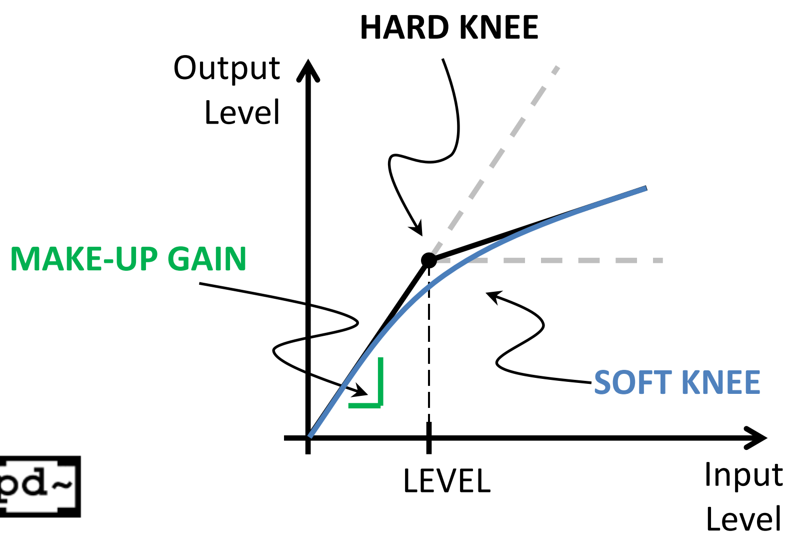


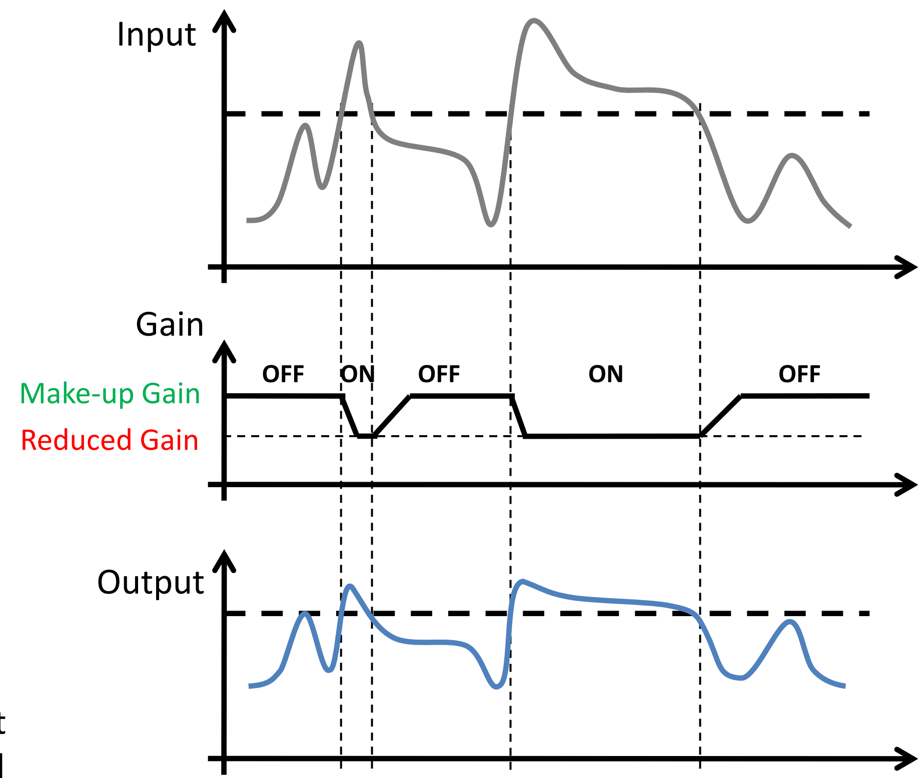


Dynamic Range Compressor (iv)

Further available controls, depending on application:

- ATTACK / RELEASE TIMES
- HARD vs SOFT KNEE
- MAKE-UP GAIN





pd~

03_stomp_dynamics_4.pd