Nonlinear Processing

compressor, limiter, noise gate, etc.

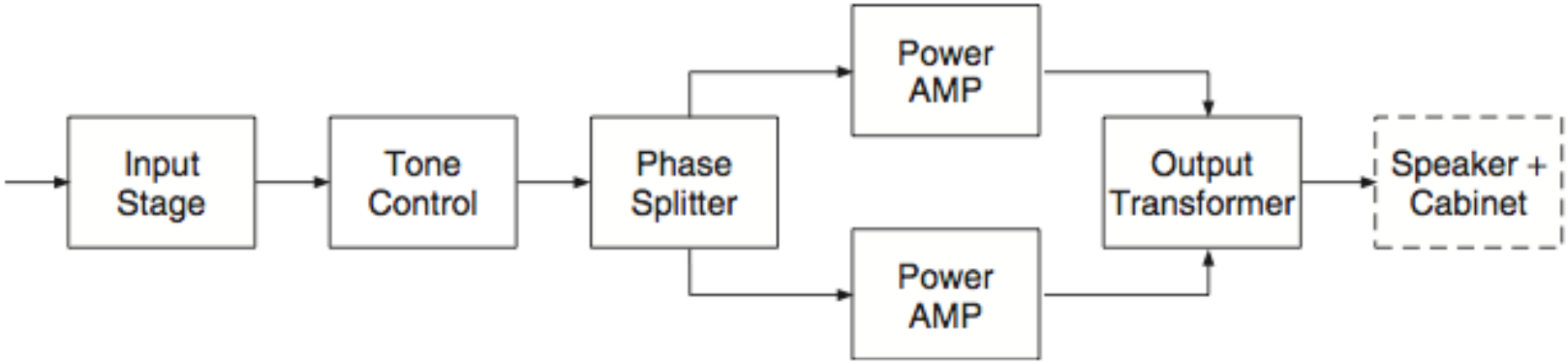
Weibin Shen

Nonlinear Processing

tube, overdrive, distortion, fuzz, harmonic gen, tape saturation

Shaoduo Xie

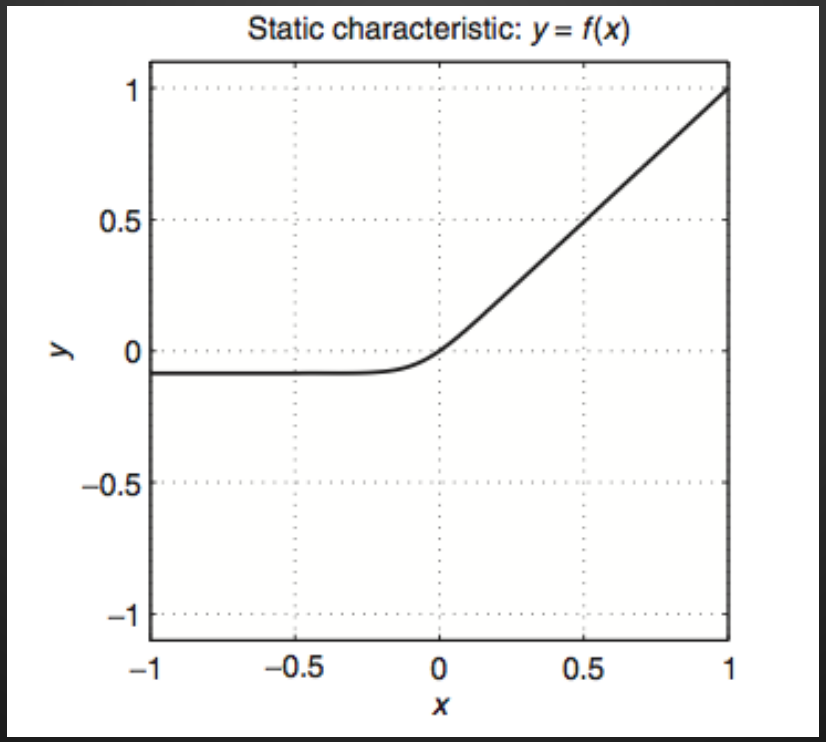
Tube Simulation



- The *tone control* circuitry is based on passive filter networks, typically with three controls for bass, mid and treble.
- The *phase splitter* stage provides symmetrical power amp feeding. This phase splitter delivers the original input for the upper power amp and a phase inverted replica of the input for the lower power amp.
- The *power amp* stage in push-pull configuration performs individual amplification of the original and the phase inverted replica in a class A, class B or class AB configuration (see Figure 4.24). Class A is shown in the left plot, where the output signal is valid all the

Tube Simulation

$$f(x) = \begin{cases} \frac{x-Q}{1-e^{-dist\cdot(x-Q)}} + \frac{Q}{1-e^{dist\cdot Q}}, & Q \neq 0, x \neq Q, \\ \frac{1}{dist} + \frac{Q}{1-e^{dist\cdot Q}}, & x = Q. \end{cases}$$



Overdrive

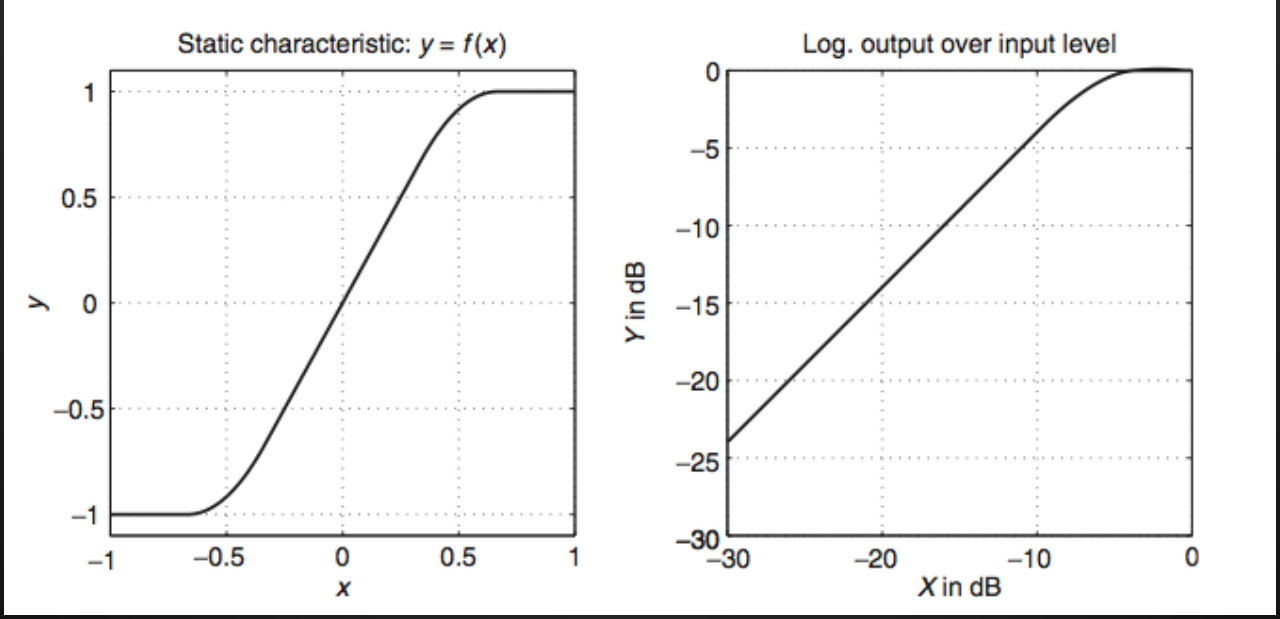
Create higher harmonics in a faster way and at a much lower sound level compared to valve amplifiers.

$$f(x) = \begin{cases} 2x & \text{for} \quad 0 \le x \le 1/3 \\ \frac{3-(2-3x)^2}{3} & \text{for} \quad 1/3 \le x \le 2/3 \\ 1 & \text{for} \quad 2/3 \le x \le 1. \end{cases}$$

Nearly linear at low input levels; high input levels are in the nonlinear part.

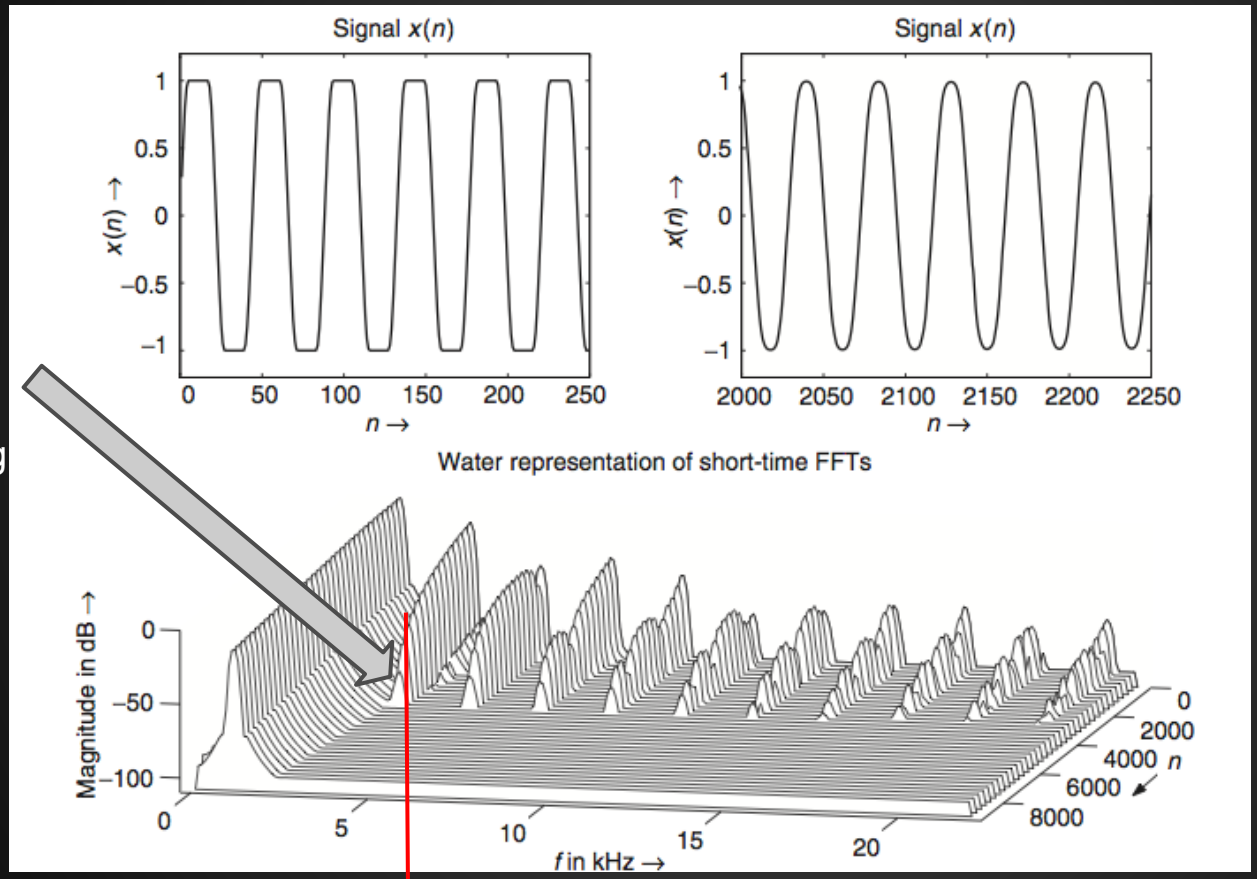
Overdrive

$$f(x) = \begin{cases} 2x & \text{for} \quad 0 \le x \le 1/3 \\ \frac{3-(2-3x)^2}{3} & \text{for} \quad 1/3 \le x \le 2/3 \\ 1 & \text{for} \quad 2/3 \le x \le 1. \end{cases}$$



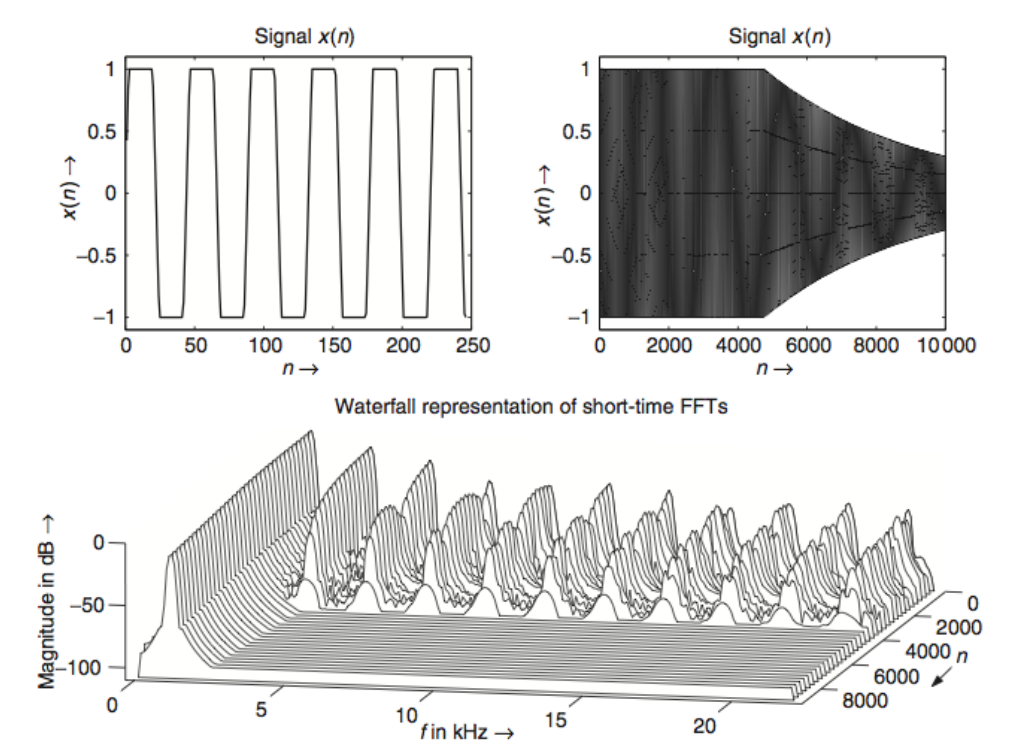
Overdrive

Lower thre of soft clipping



Soft clipping

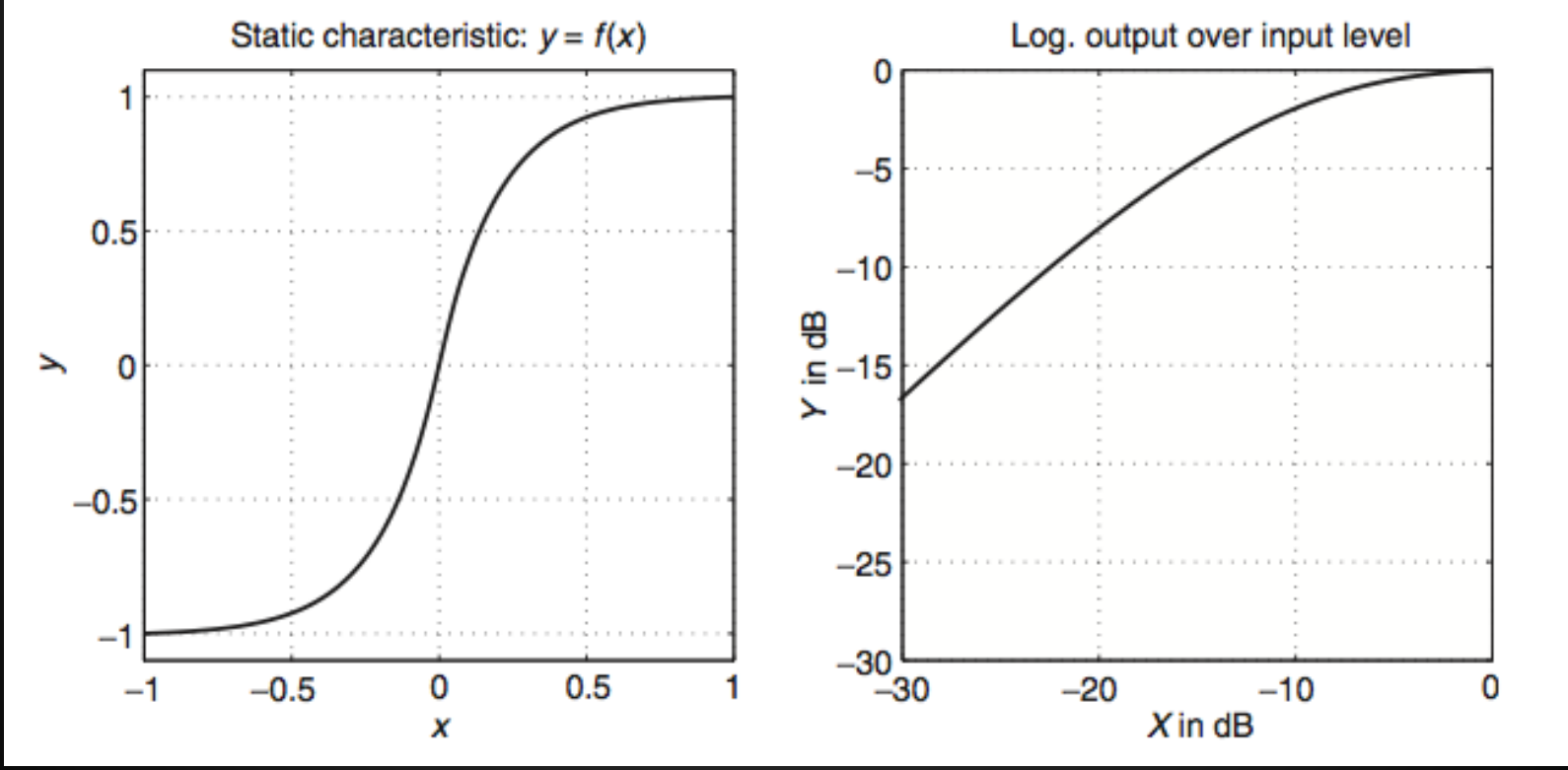
Overdrive



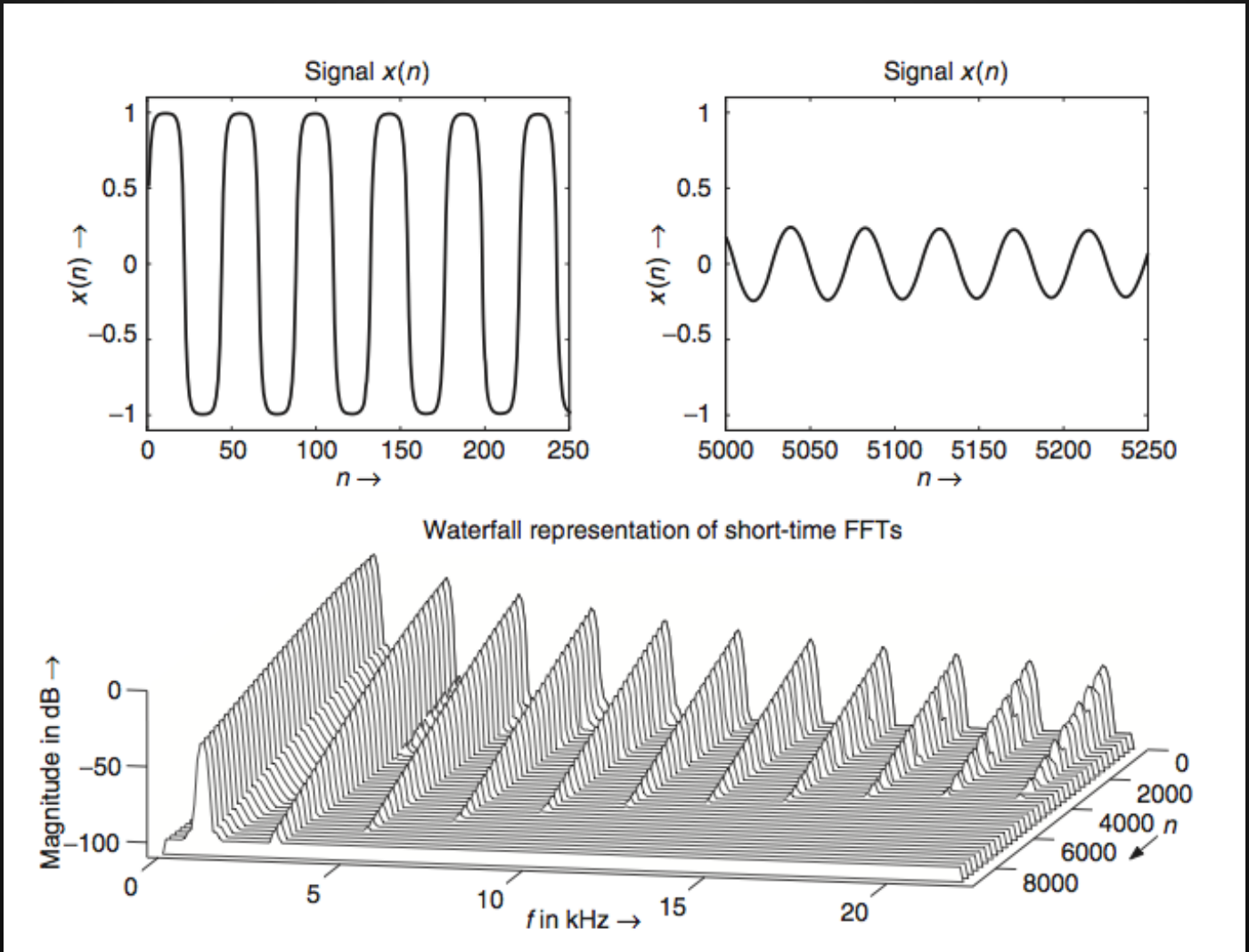
Hard clipping: higher harmonics have high levels.

Distortion

$$f(x) = \operatorname{sgn}(x)\left(1 - \mathrm{e}^{-|x|}\right).$$



Distortion


Signal $x(n)$
1
0.5
0
−0.5
−1
$x(n) \rightarrow$
0
50
100
150
200
250
$n \rightarrow$
Signal $x(n)$
1
0.5
0
−0.5
−1
$x(n) \rightarrow$
5000
5050
5100
5150
5200
5250
$n \rightarrow$
Waterfall representation of short-time FFTs
Magnitude in dB →
0
−50
−100
0
5
10
15
20
f in kHz →
0
2000
4000
6000
8000
n

Overdrive & Distortion

DAFX demo & others

Others:
x -> gain -> HP -> tanh -> LP -> tanh -> y

KEY: ASYMMETRICAL

Fuzz

2nd Harmonic

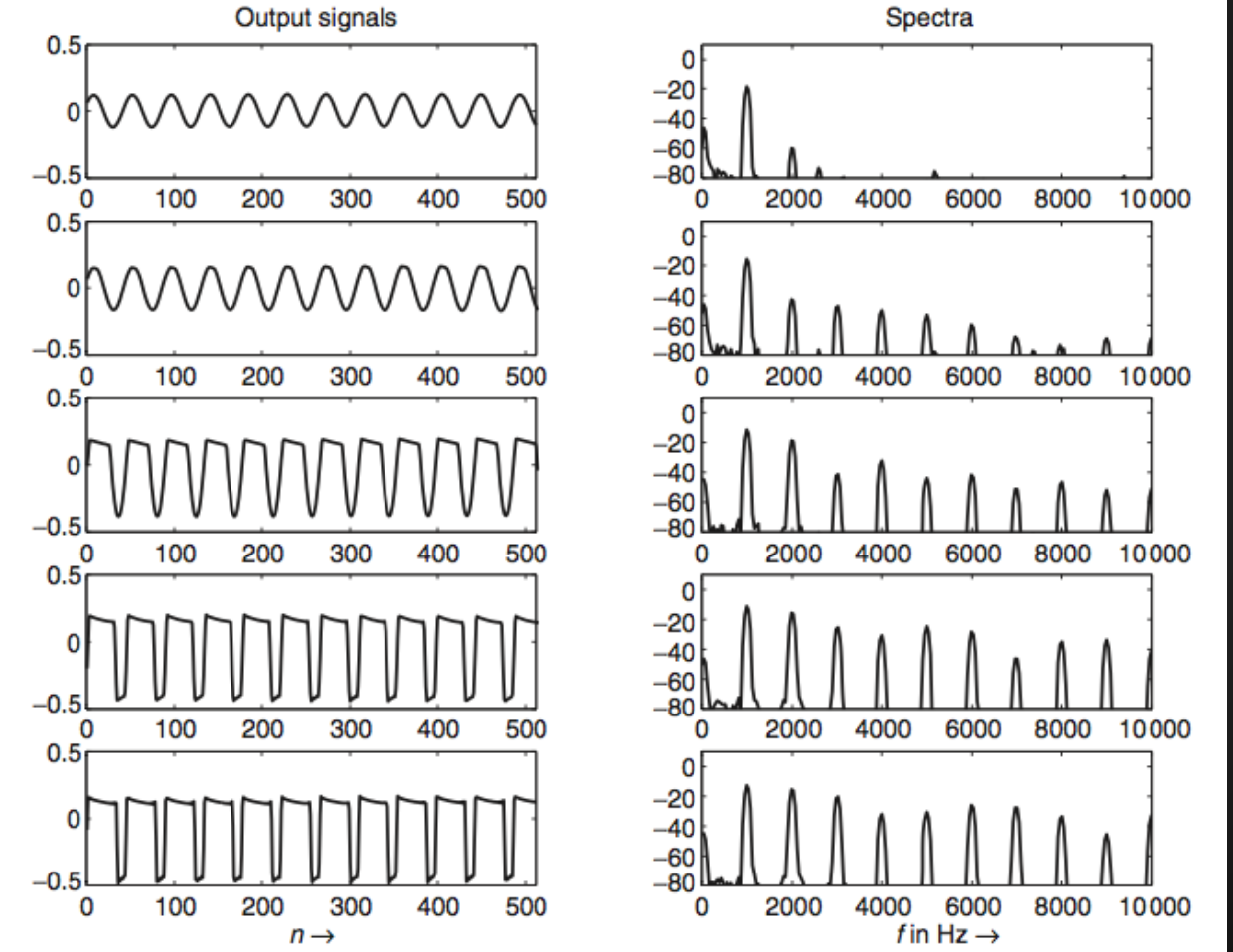
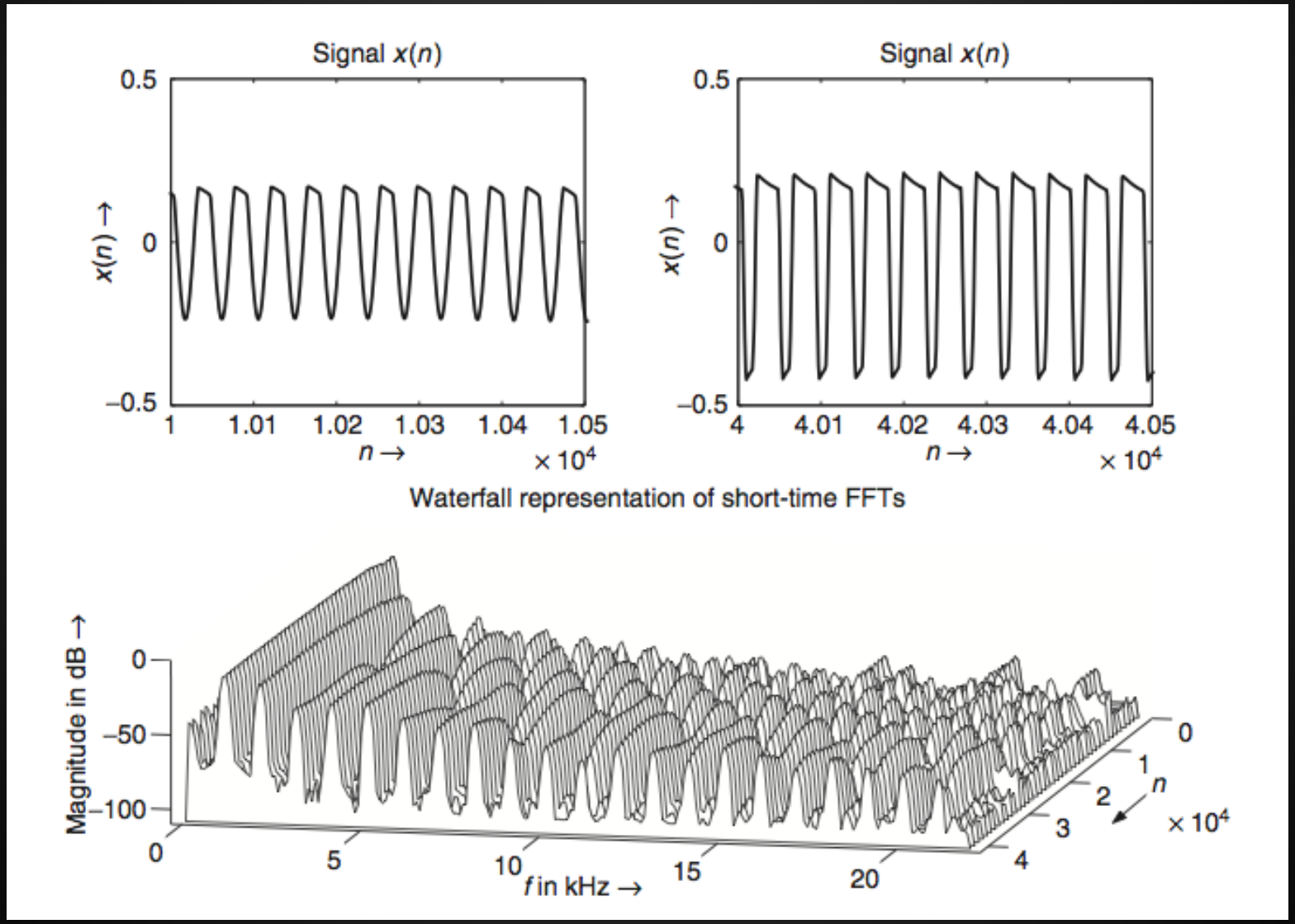


Figure 4.34 Signals and corresponding spectra of Fuzz Face.

Even harmonics enhanced

negative starts clipping (asymmetrical)

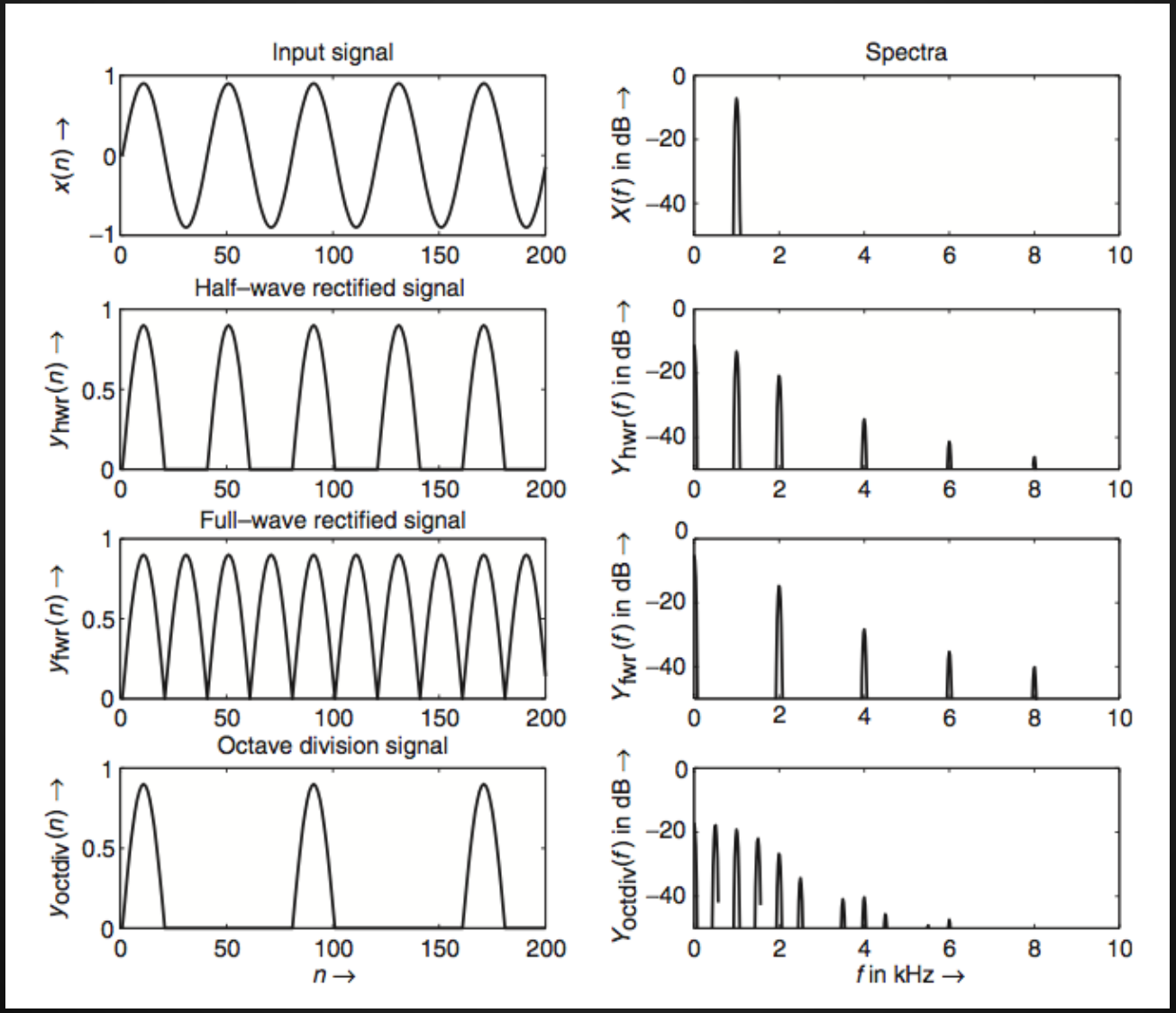
Fuzz


Signal x(n)
0.5
0
−0.5
x(n) →
1
1.01
1.02
1.03
1.04
1.05
n →
× 10^4
Signal x(n)
0.5
0
−0.5
x(n) →
4
4.01
4.02
4.03
4.04
4.05
n →
× 10^4
Waterfall representation of short-time FFTs
Magnitude in dB →
0
−50
−100
0
5
10
15
20
f in kHz →
0
1
2
3
4
n
× 10^4

Fuzz

Commercial products demo

Harmonic & Subharmonic gen



even harmonics

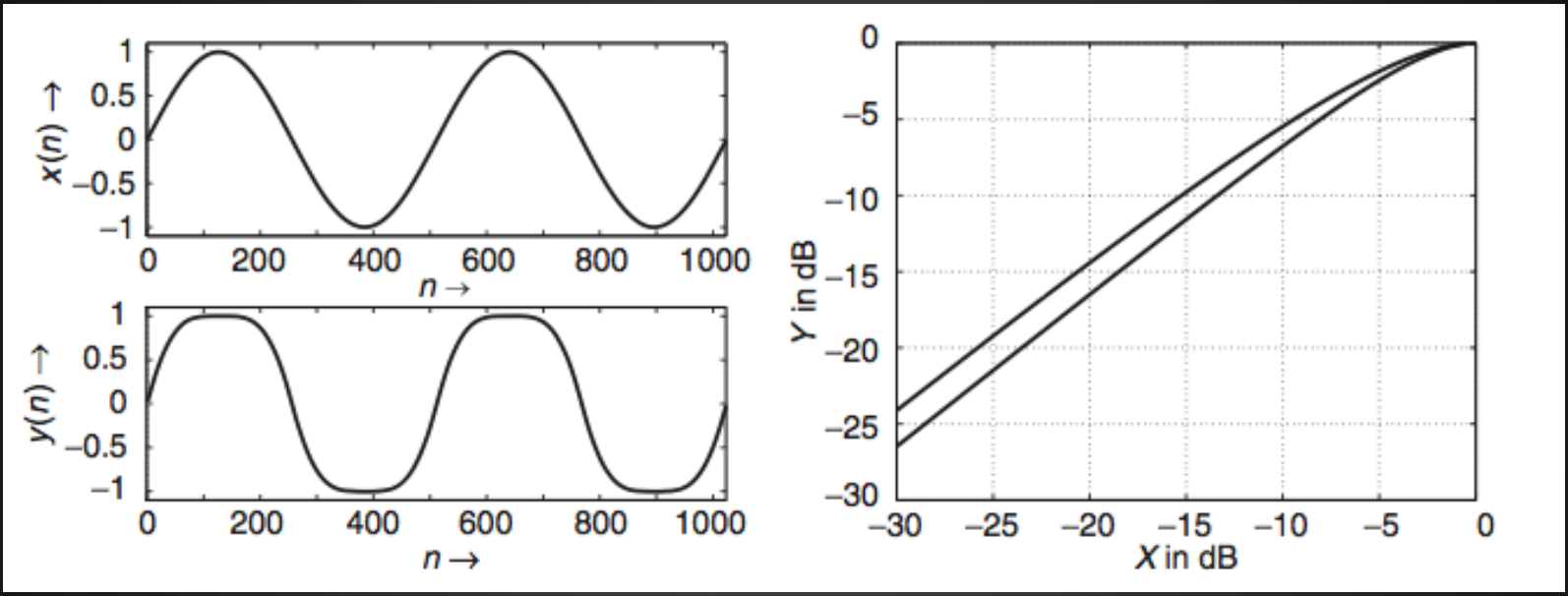
no F0

change octave

Harmonic & Subharmonic gen

Commercials Demo

Tape Saturation



Tape Saturation