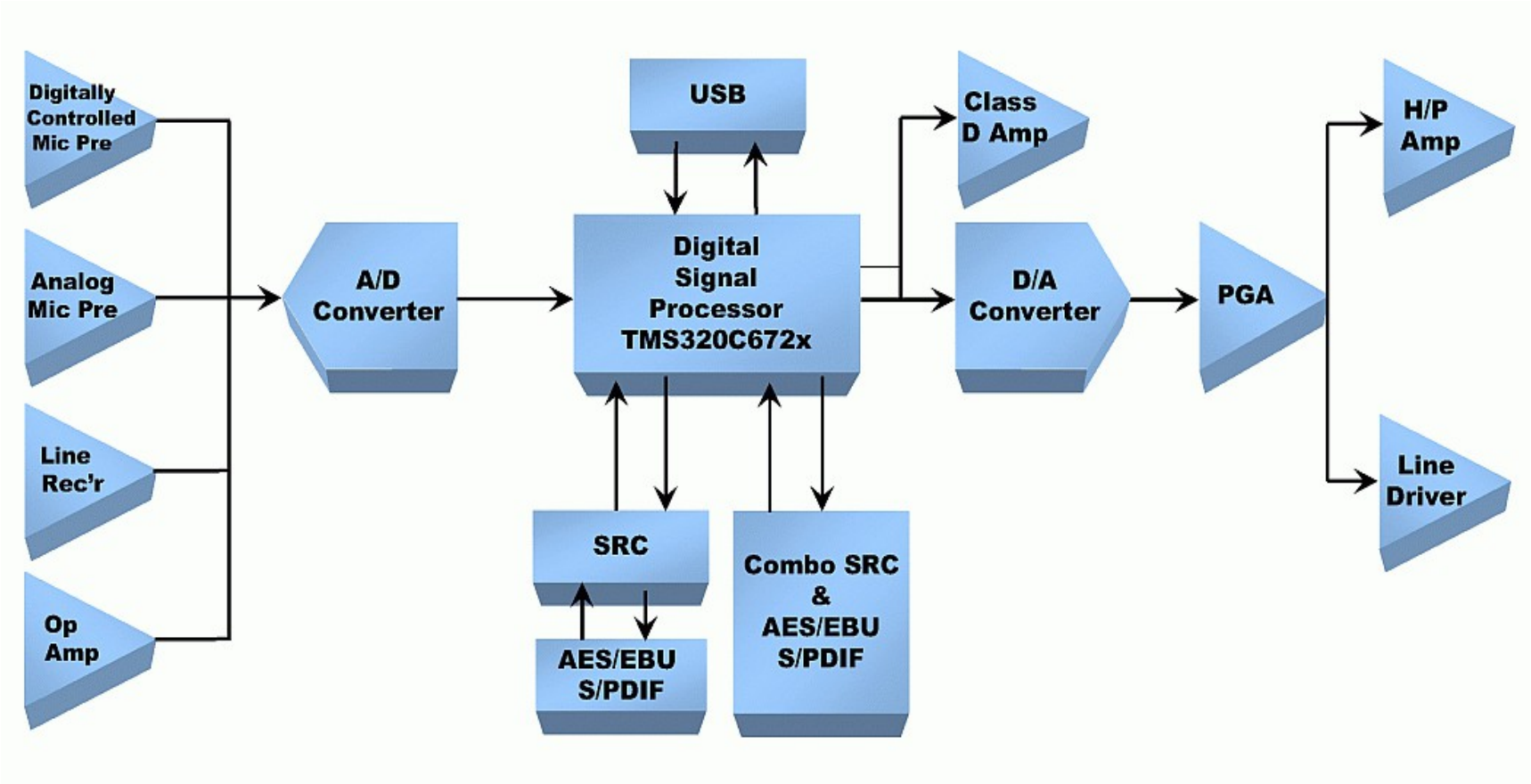
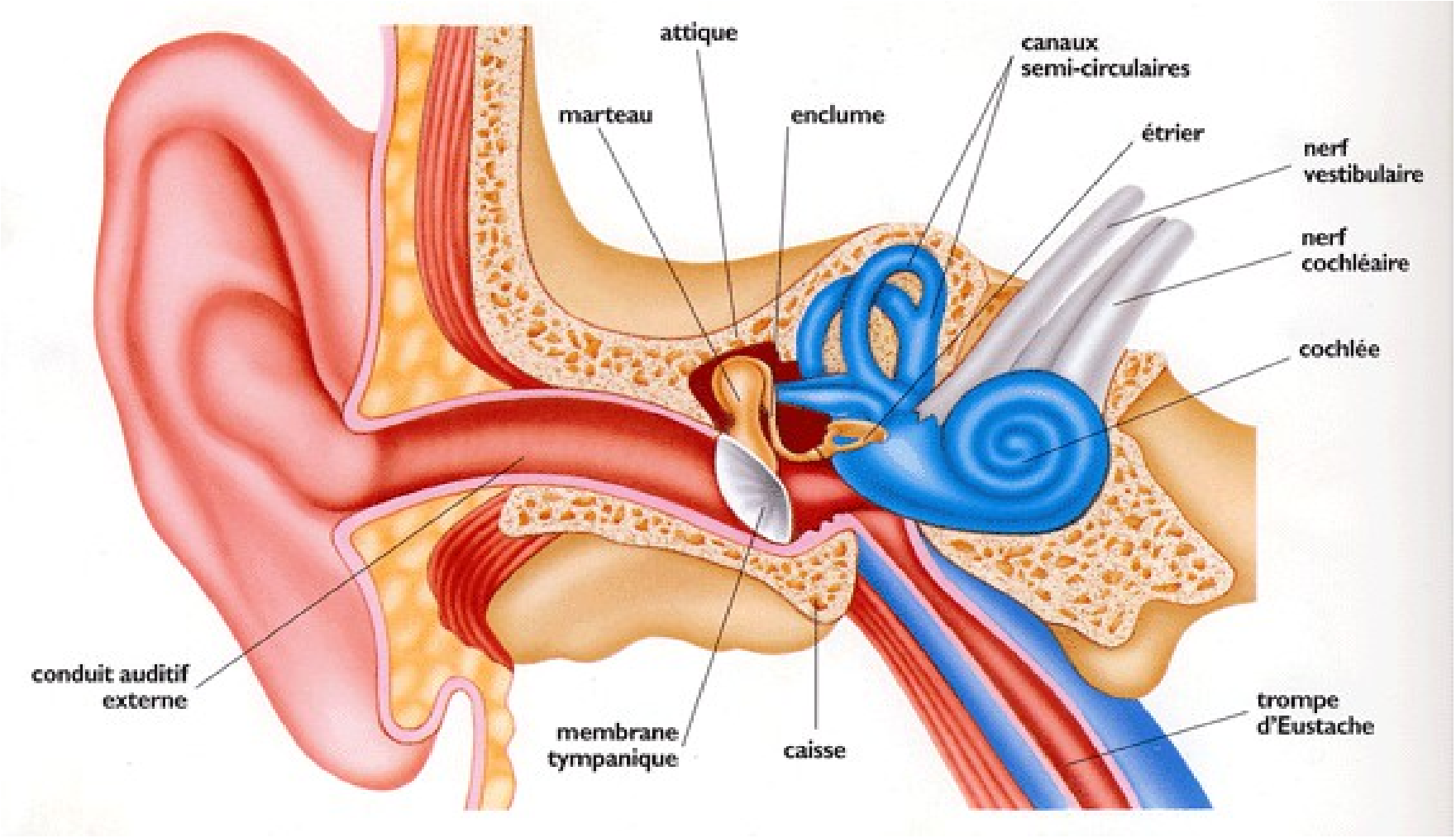
# audionumérique

- Chaîne d'acquisition/traitement/restitution de l'information audio
- Musique vs parole
- Streaming internet
- Audio embarqué
- Audionumérique pour la radio, le cinéma, la production musicale
- Architectures – algorithmes – normes

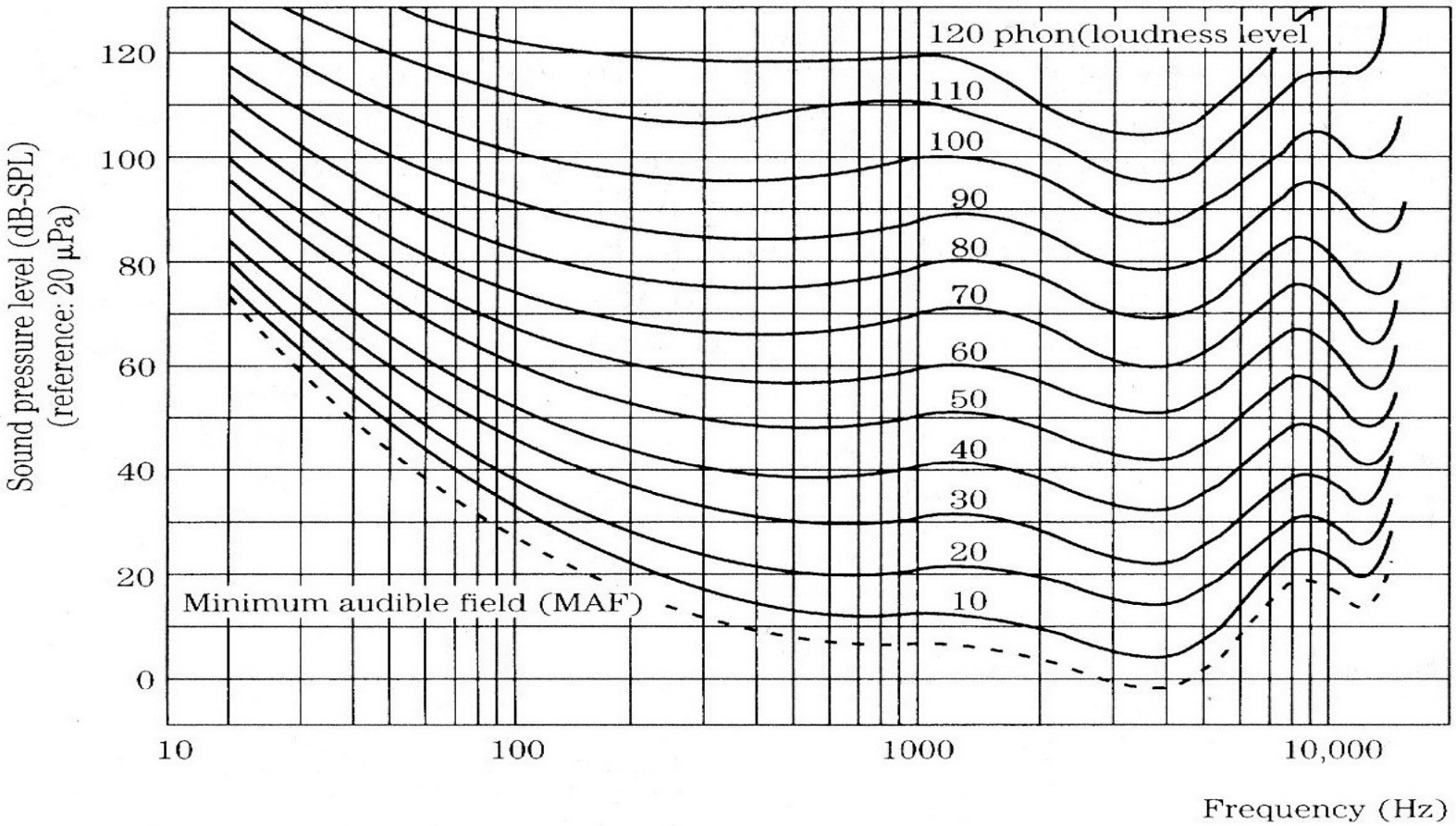
# Architectures standards



# L'oreille


attique
canaux
semi-circulaires
marteau
enclume
étrier
nerf
vestibulaire
nerf
cochléaire
cochlée
conduit auditif
externe
membrane
tympanique
caisse
trompe
d'Eustache

# La dynamique de l'oreille



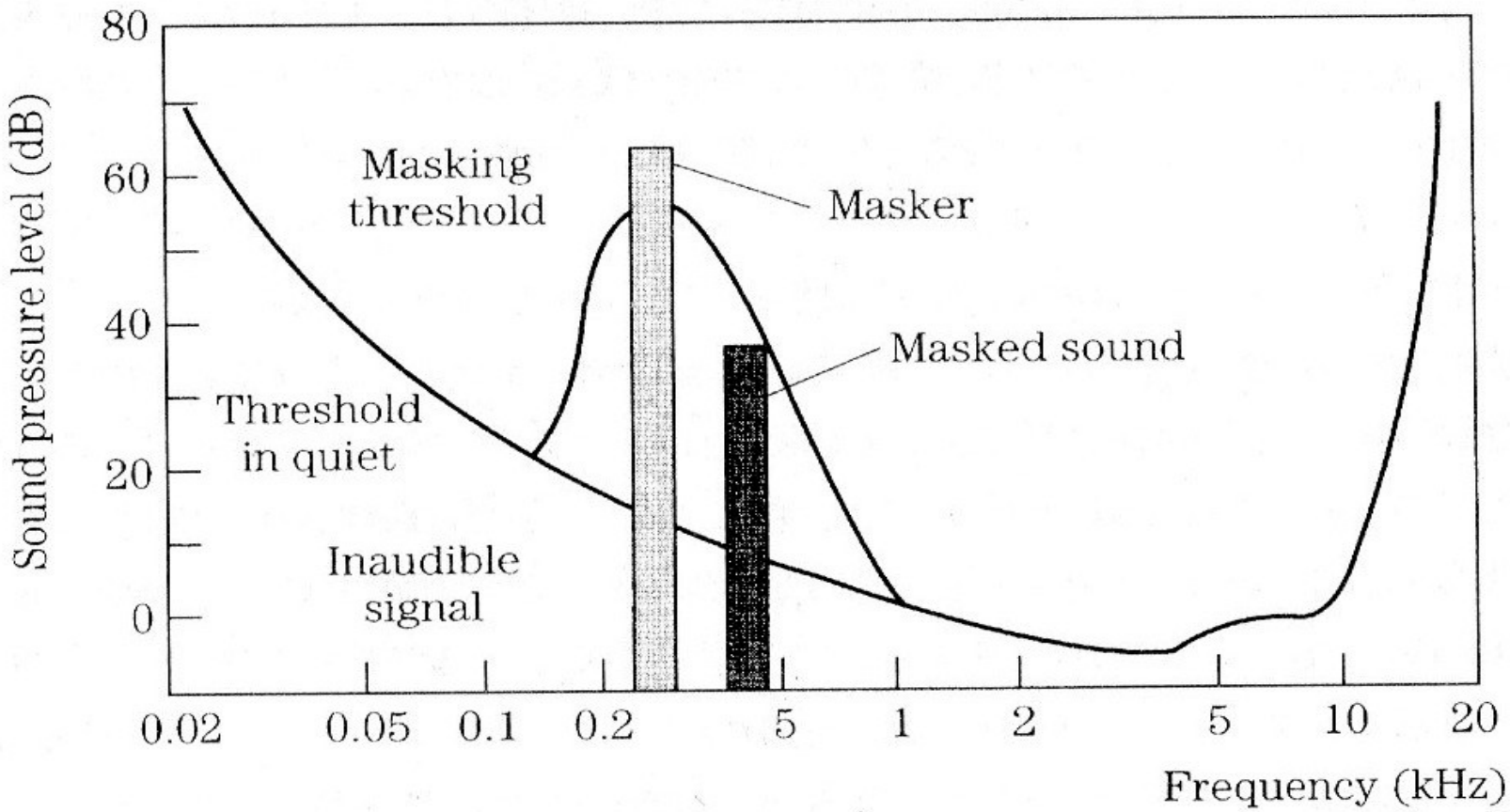
# Les bandes critiques

**TABLE 10.1 An example of critical bands in the human hearing range showing increase in bandwidth with absolute frequency. A critical band will arise at an audible sound at any frequency.**

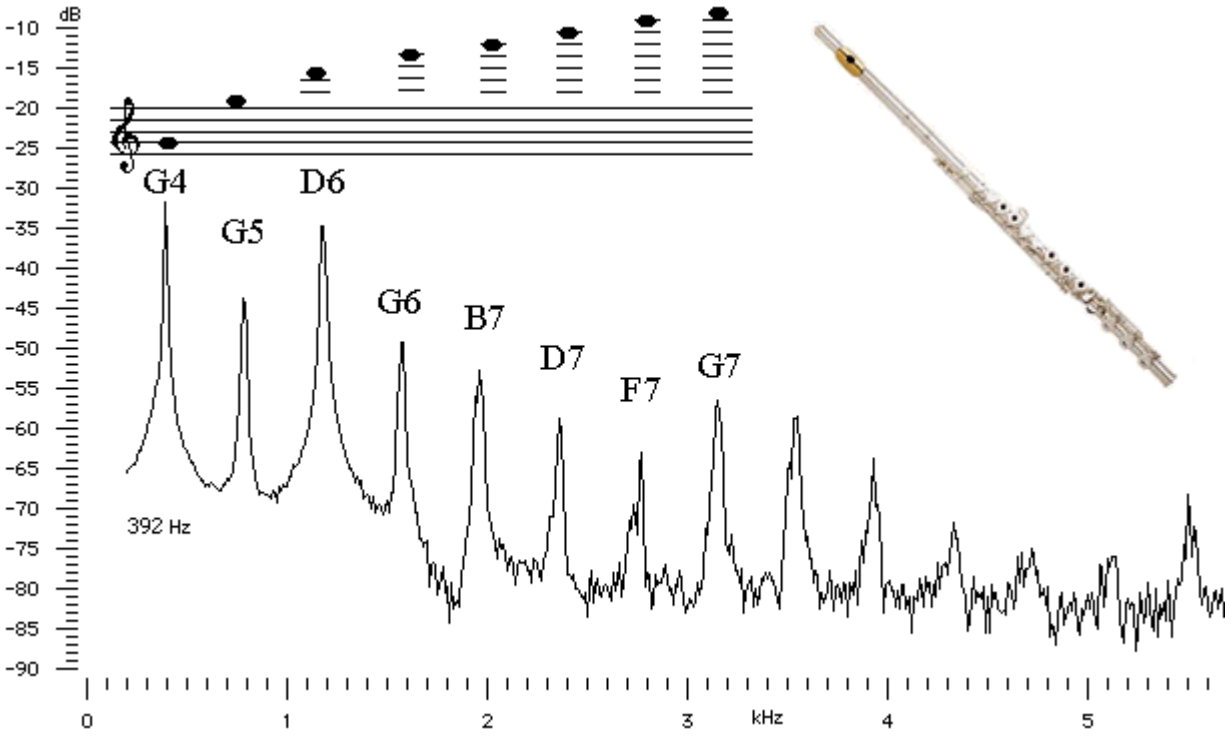
| Critical band number (Bark) | Center freuqency (Hz) | Critical band (Hz) | Lower cutoff frequency (Hz) | Upper cutoff frequency (Hz) |
|---|---|---|---|---|
| 1 | 50 | — | — | 100 |
| 2 | 150 | 100 | 100 | 200 |
| 3 | 250 | 100 | 200 | 300 |
| 4 | 350 | 100 | 300 | 400 |
| 5 | 450 | 110 | 400 | 510 |
| 6 | 570 | 120 | 510 | 630 |
| 7 | 700 | 140 | 630 | 770 |
| 8 | 840 | 150 | 770 | 920 |
| 9 | 1000 | 160 | 920 | 1080 |
| 10 | 1170 | 190 | 1080 | 1270 |
| 11 | 1370 | 210 | 1270 | 1480 |
| 12 | 1600 | 240 | 1470 | 1720 |
| 13 | 1850 | 280 | 1720 | 2000 |
| 14 | 2500 | 320 | 2000 | 2320 |
| 15 | 2900 | 380 | 2320 | 2700 |
| 16 | 2900 | 450 | 2700 | 3150 |
| 17 | 3400 | 550 | 3150 | 3700 |
| 18 | 4000 | 700 | 3700 | 4400 |
| 19 | 4800 | 900 | 4400 | 5300 |
| 20 | 5800 | 1100 | 5300 | 6400 |
| 21 | 7000 | 1300 | 6400 | 7700 |
| 22 | 8500 | 1800 | 7700 | 9500 |
| 23 | 10,500 | 2500 | 9500 | 12,000 |
| 24 | 13,500 | 3500 | 12,000 | 15,500 |
| 25 | 18,775 | 6550 | 15,500 | 22,050 |

(*Tobias*)

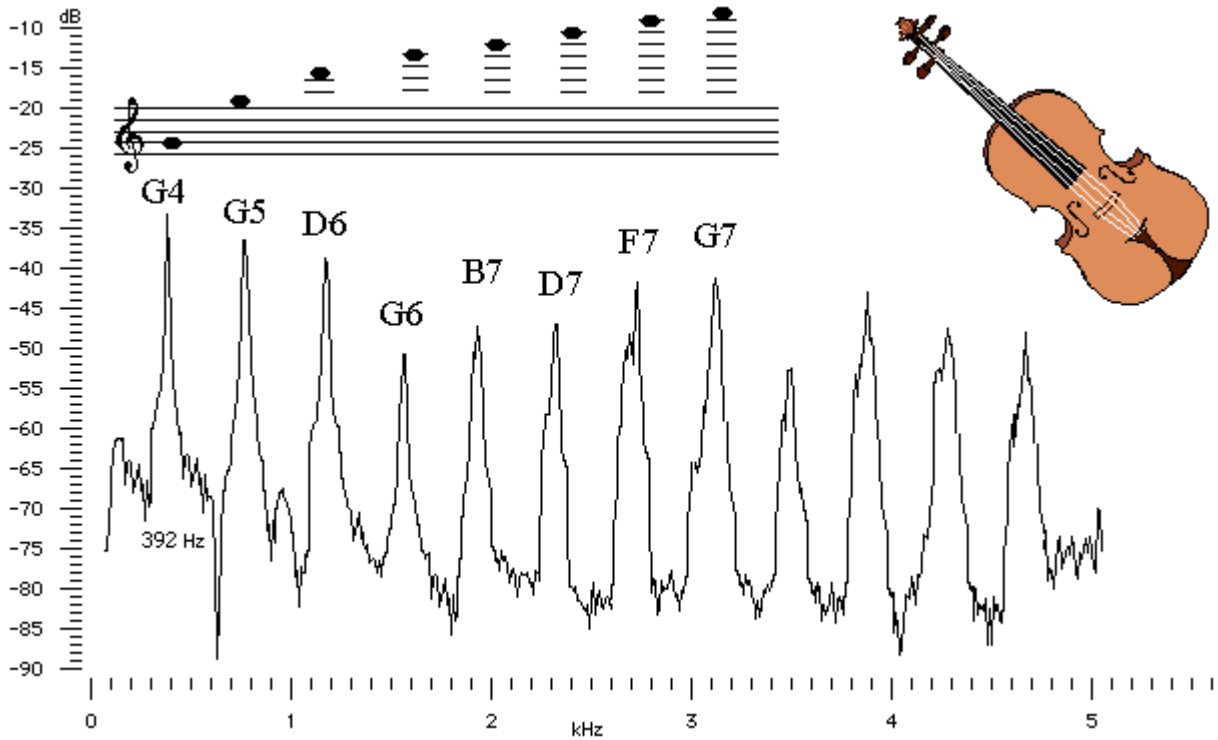
# Le masquage fréquentiel



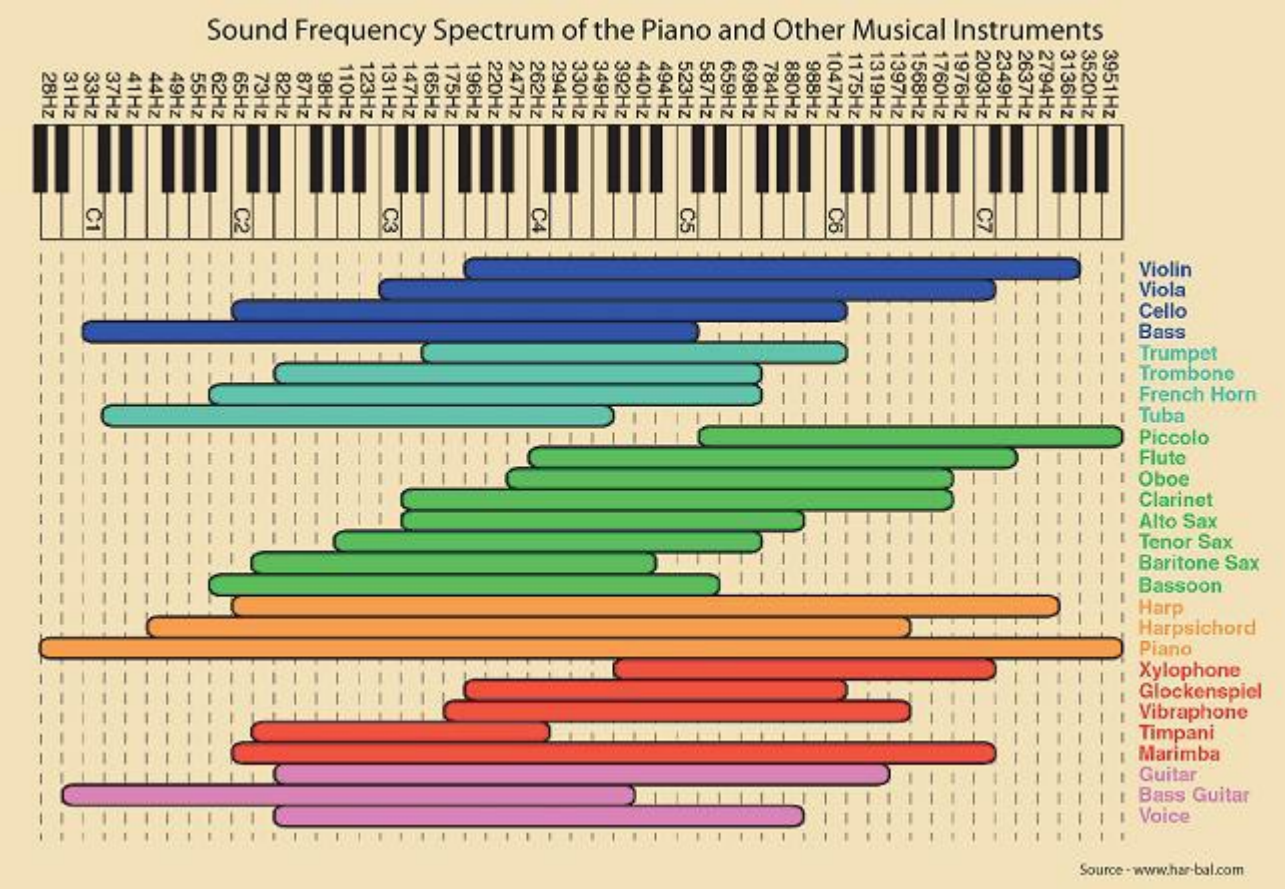
# Les harmoniques



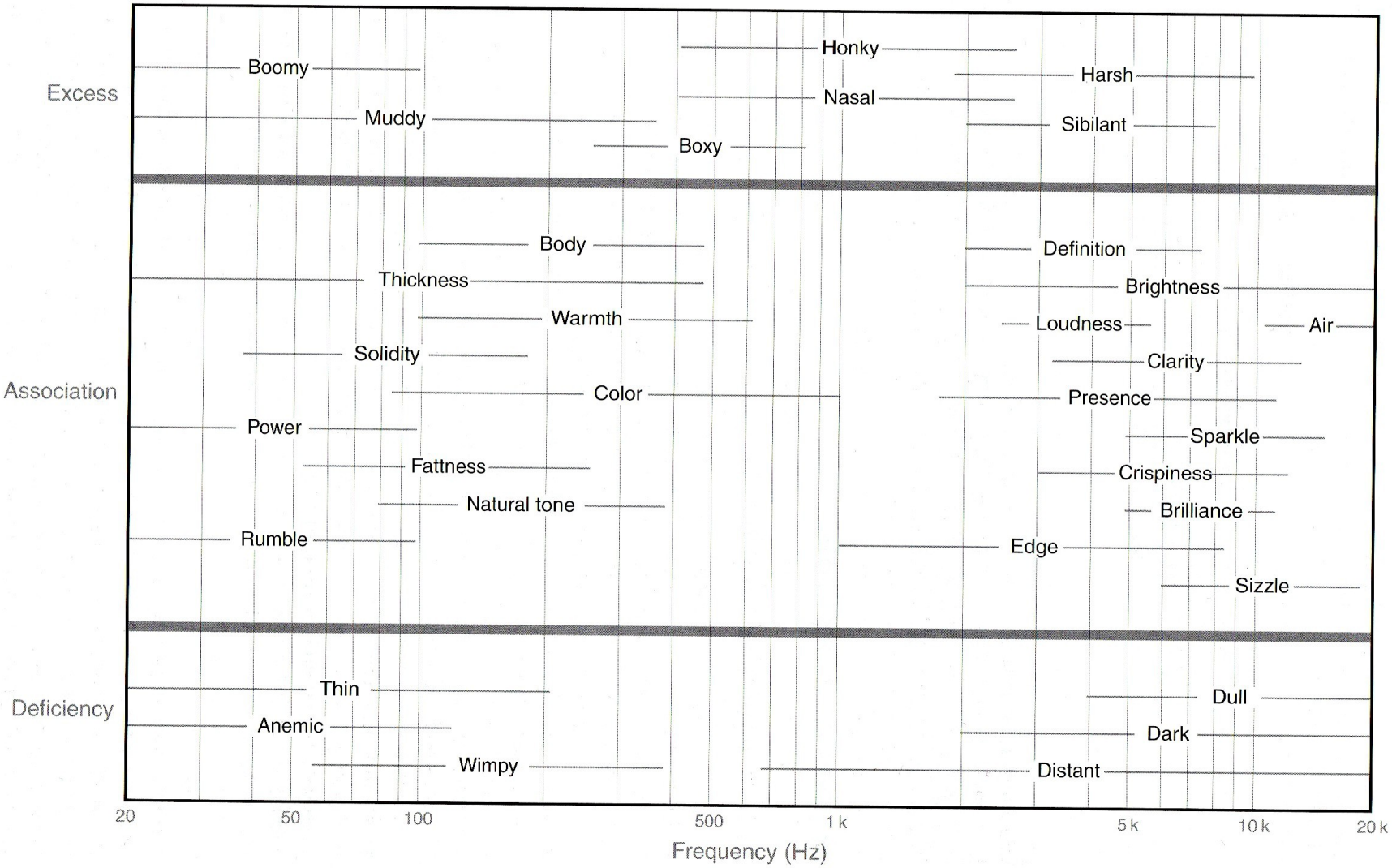
# Les harmoniques



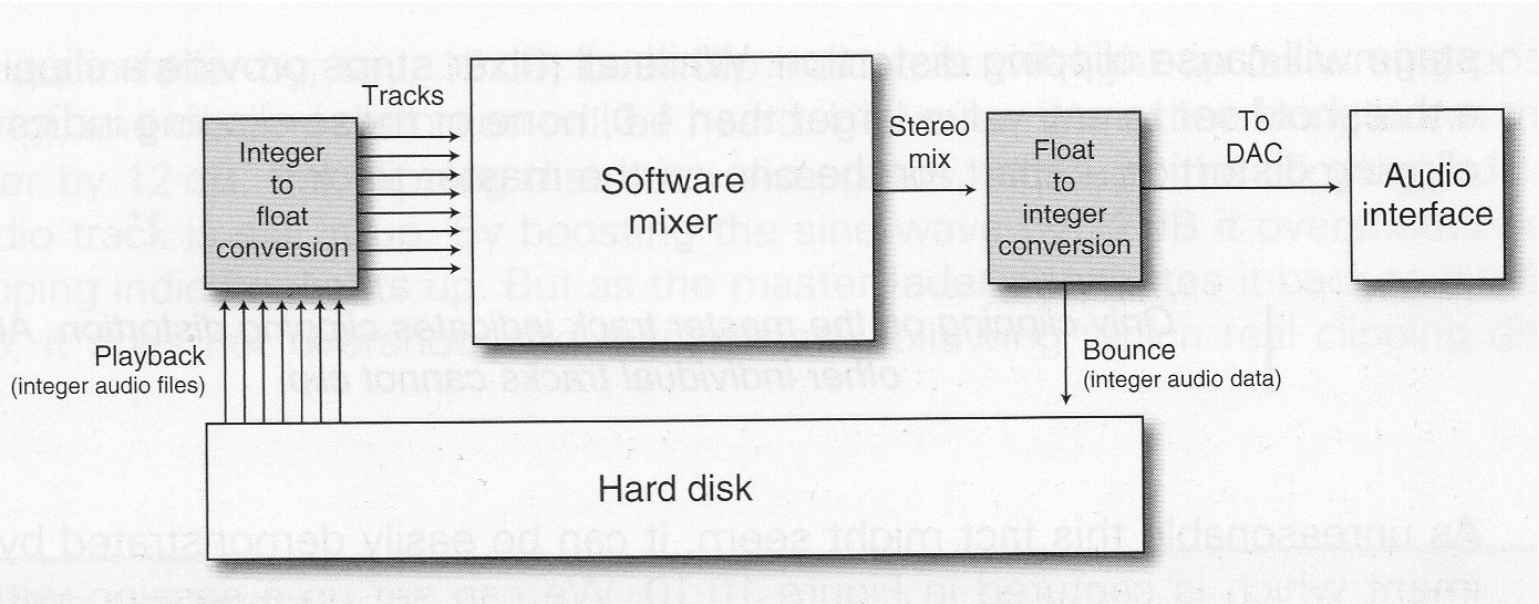
# Le spectre des sources sonores



# L'équilibre spectral



# Architecture du TSA



# Mixers virtuels

- Floating point vs Integer
- Ex : float 32 bit = 1 bit de signe + 23 bits de mantisse + 8 bits exposant

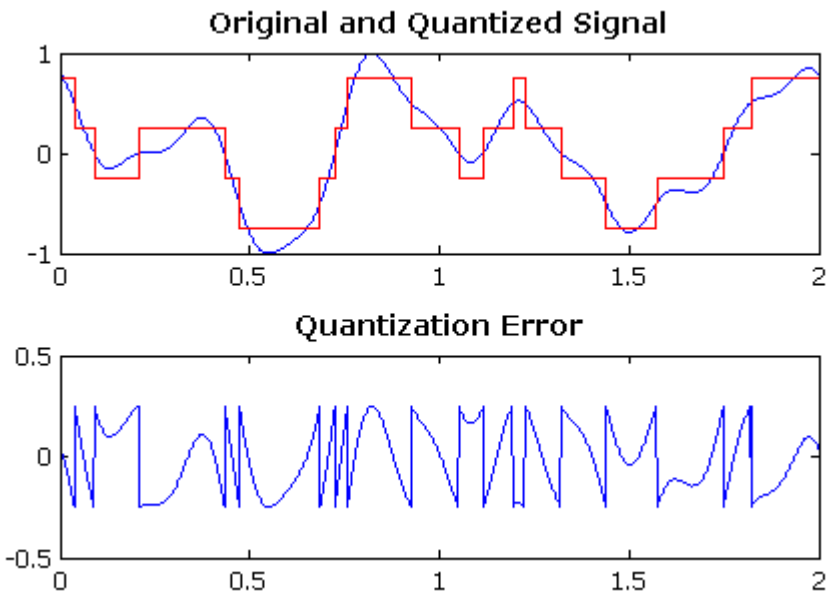
  →144 dB de dynamique et non 1638 dB
- 1.0 correspond à 0 dBr
- Dithering (ex: 1.0 / 3 = 0.333333334)

# Dithering

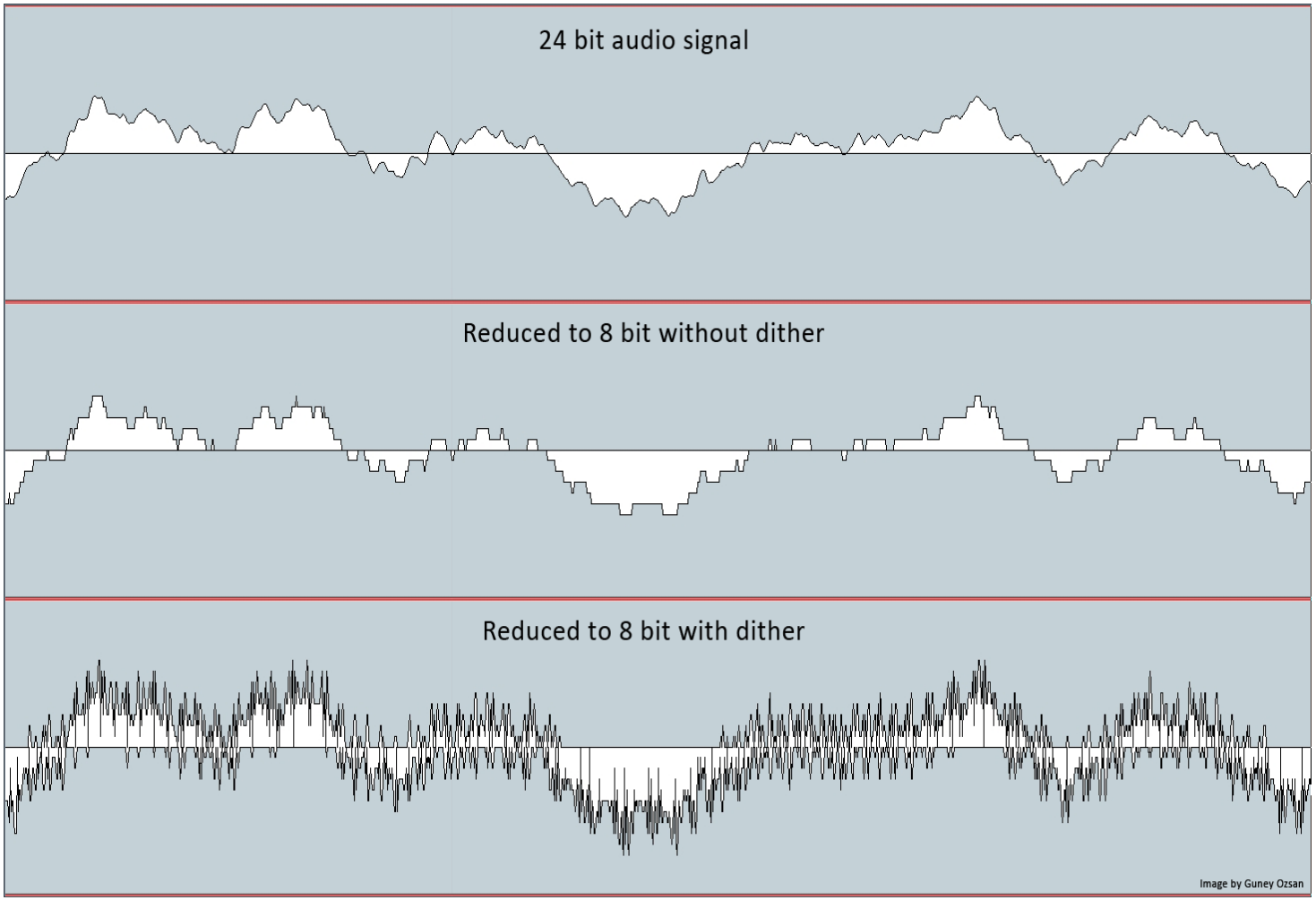
- Problèmatique : erreurs d'arrondi lorsqu'on passe de “floating point” à “integer”.
- [1 2 3 4 5] * 0.8 = [0.8 1.6 2.4 3.2 4.0]

  -> [1 1 2 3 4]
- Distortion corrélée avec le signal !
- Stratégie : ajouter un bruit uniforme avant conversion, pour décorréler.
- Exemple : 3.2 = Ent{3.2 + [0-1]}

# Dithering


Original and Quantized Signal
1
0
-1
0
0.5
1
1.5
2
Quantization Error
0.5
0
-0.5
0
0.5
1
1.5
2

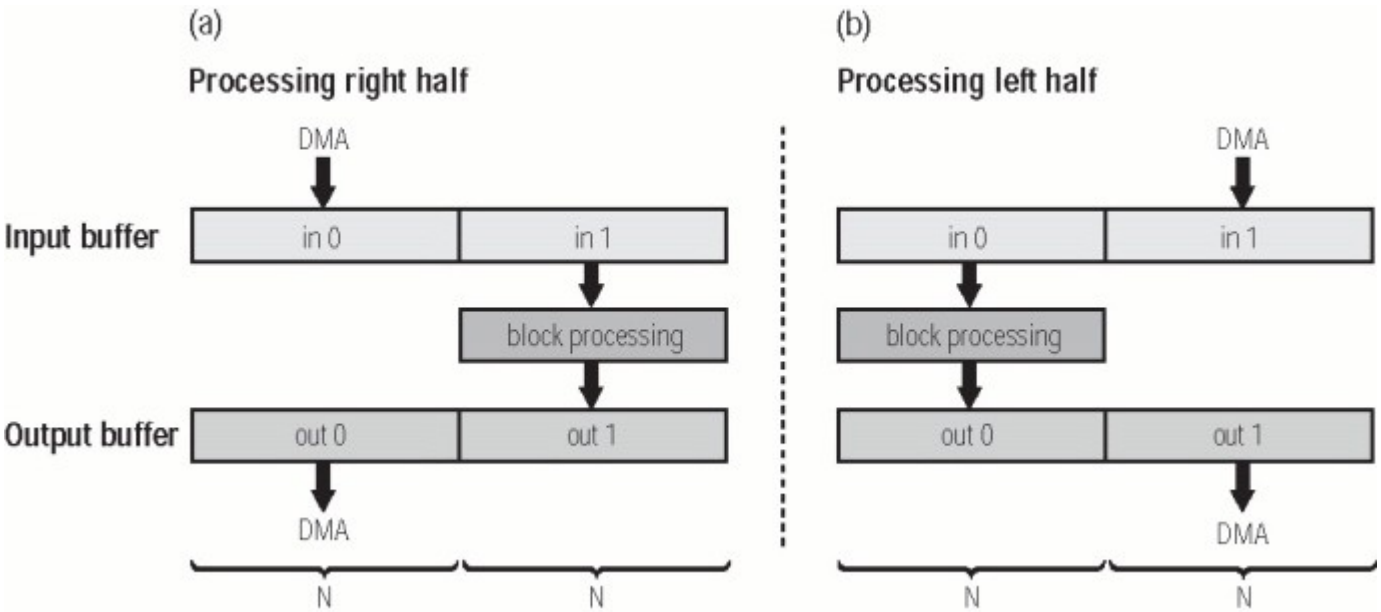
# Dithering


24 bit audio signal
Reduced to 8 bit without dither
Reduced to 8 bit with dither
Image by Guney Ozsan

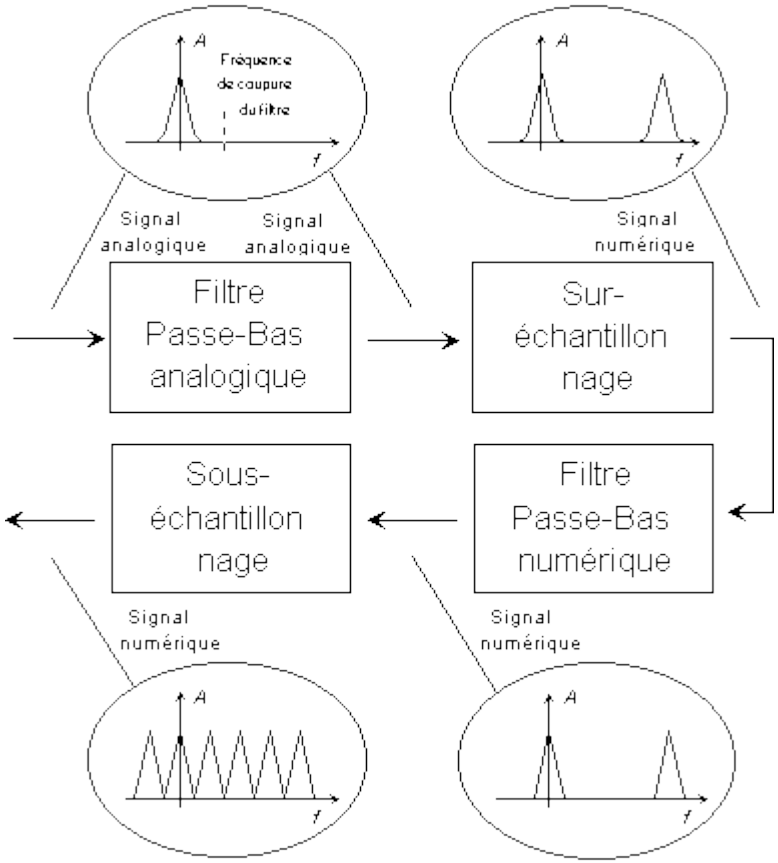
# Buffering

- Influence de la taille des buffers
- Double buffering
- Low latency mode
- Plugin delay compensation & problèmes liés à la phase (filtres en peigne)

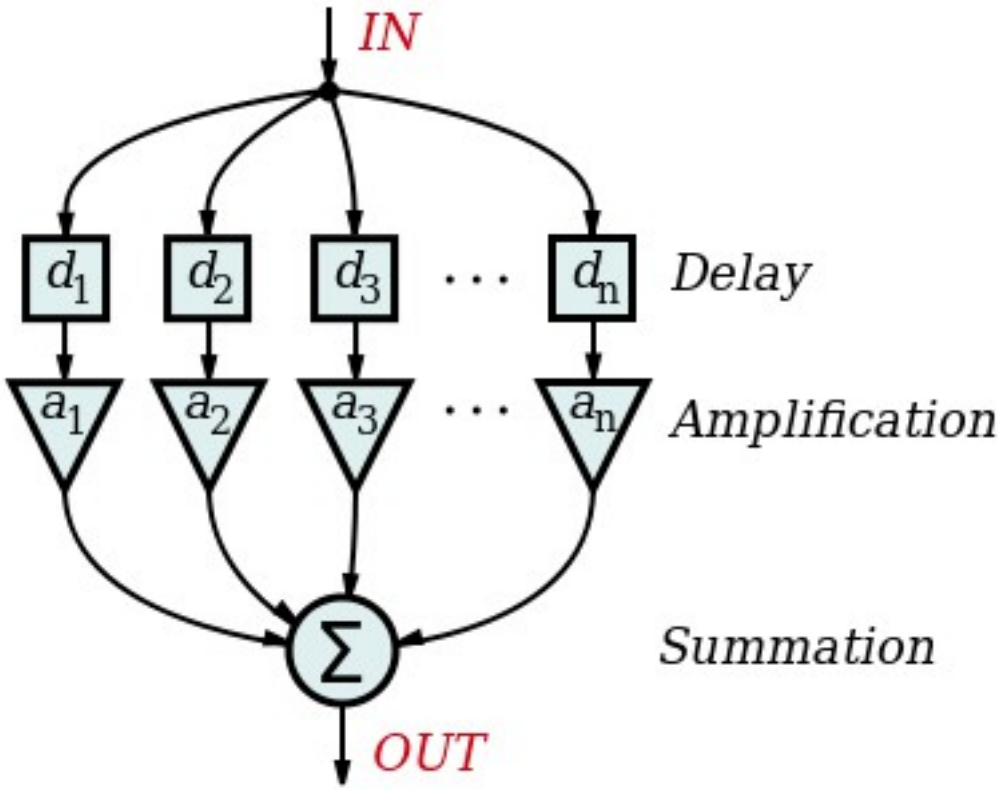
# Double Buffering & DMA



# Sur-échantillonnage

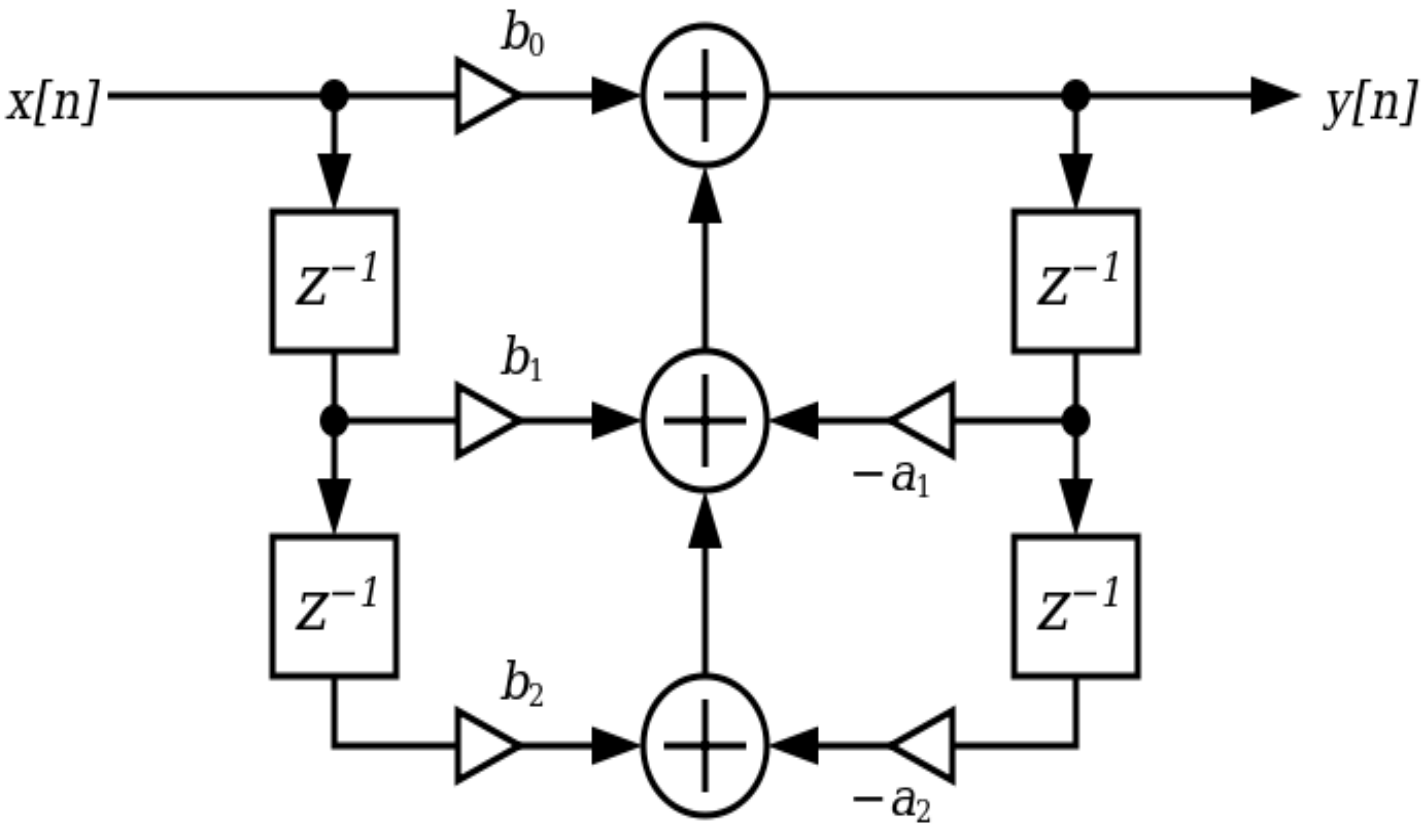


# EQ : filter design

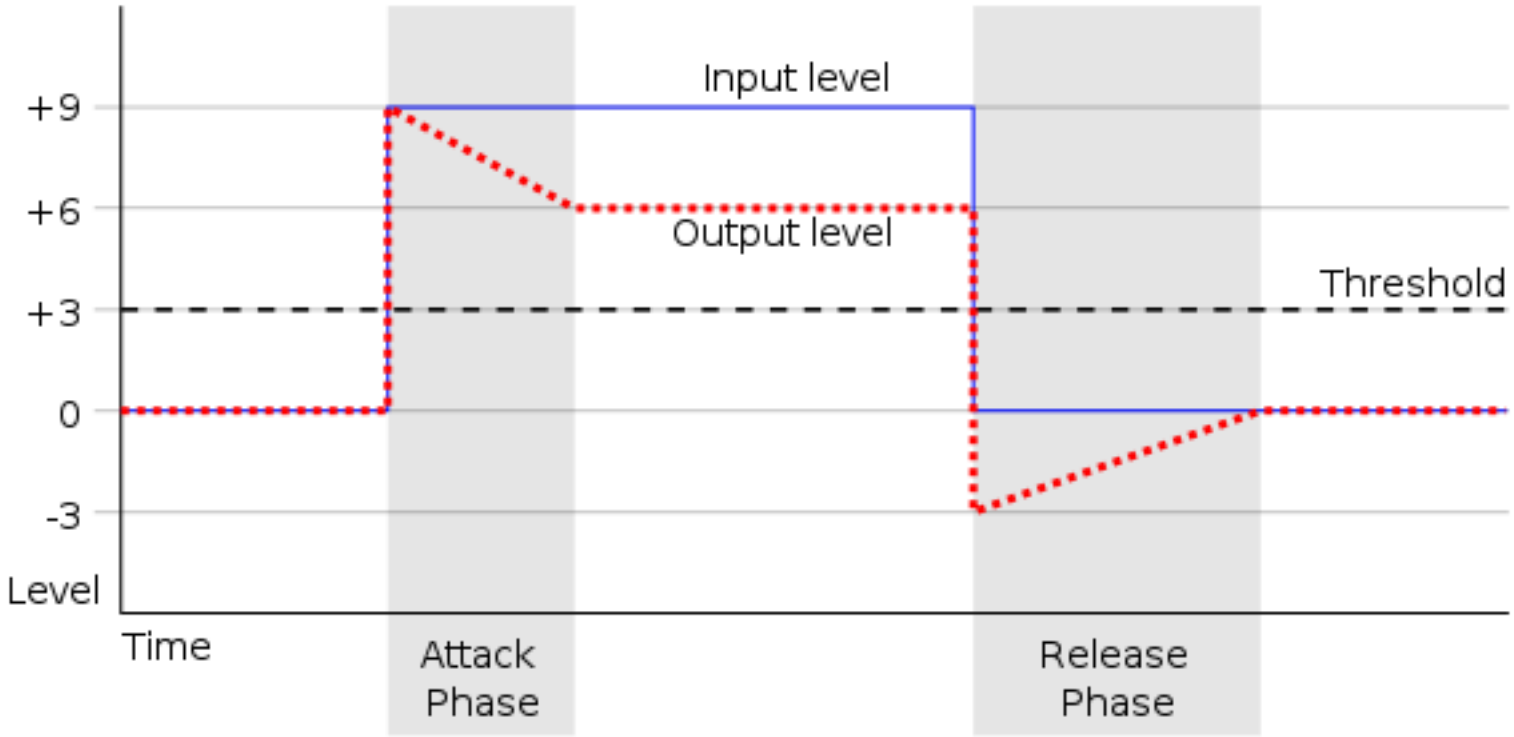


# EQ : filter design

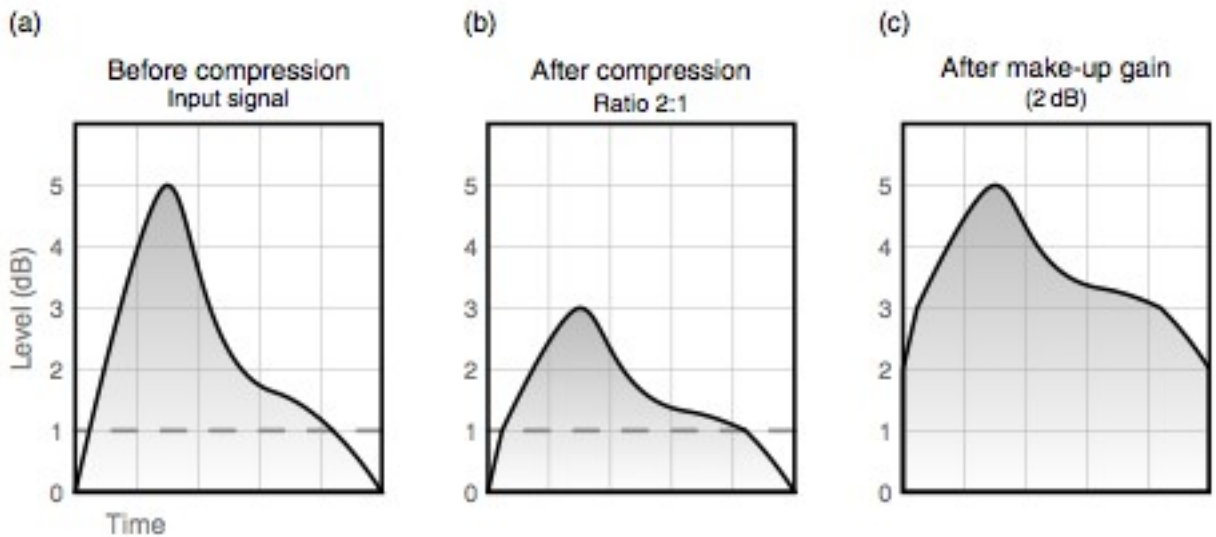
- Direct form I (instable si N grand, 2N délais)



# Compression

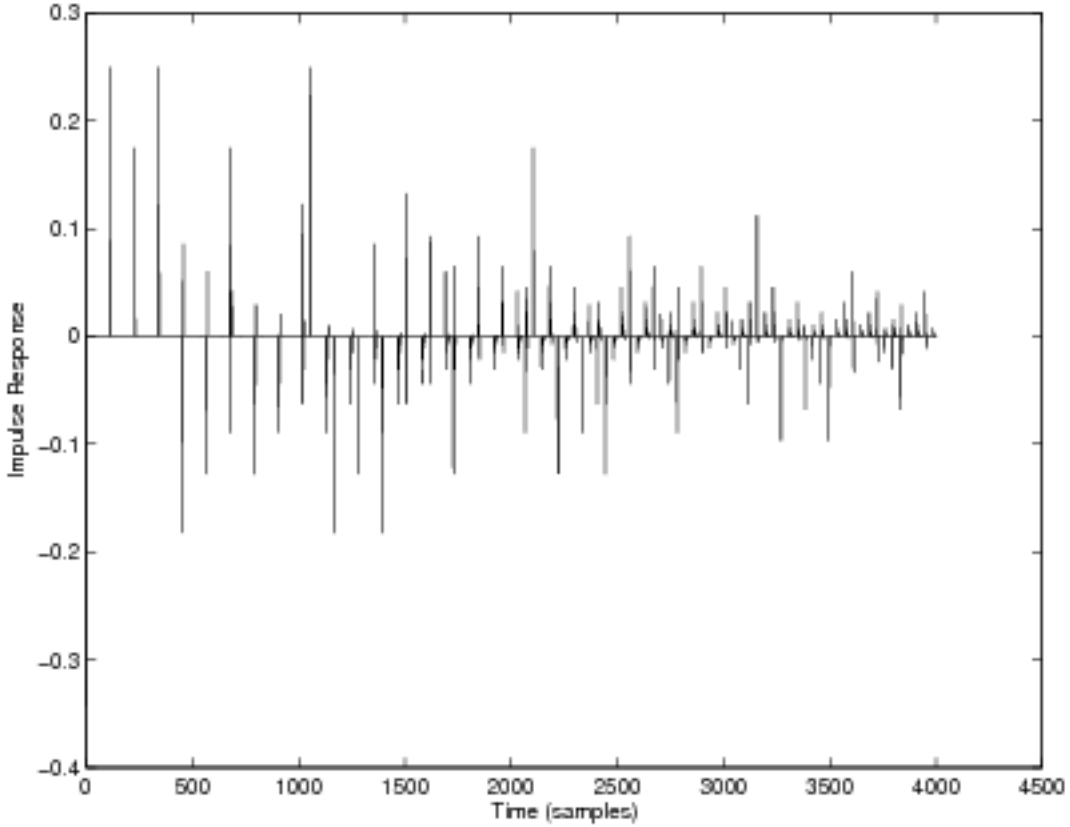


# Compression

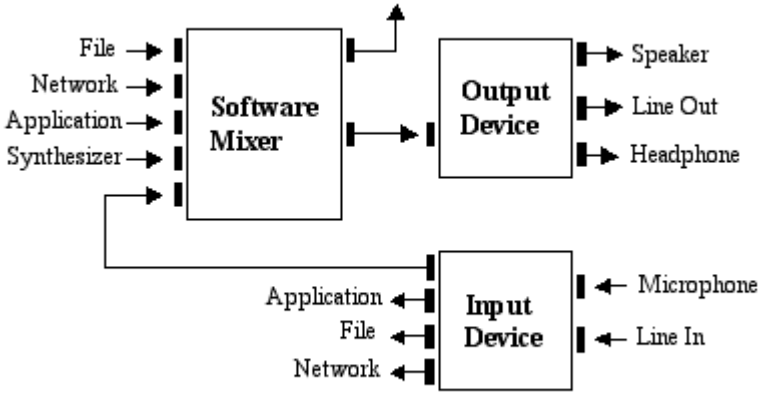
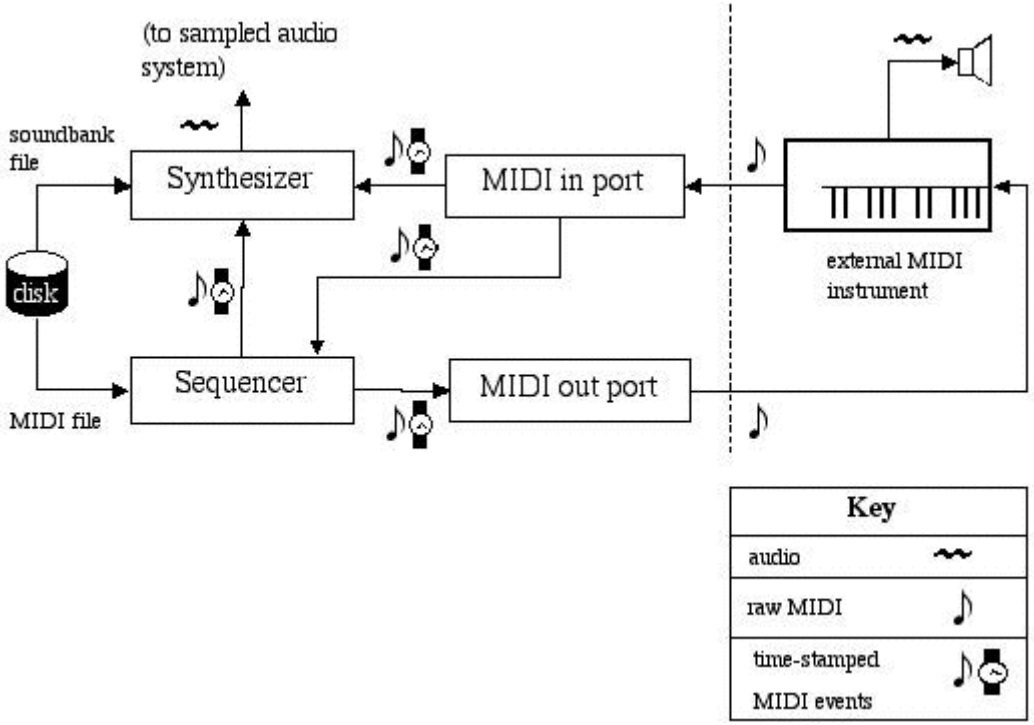


# Réverbération

- Emulation : réponse impulsionnelle.



# L'API Java Sound



# L'API Java MIDI