Digital Audio

Audio Formats

Raw, uncompressed audio:

- WAV

Lossless, compressed audio:

- FLAC (Free Lossless Audio Codec)
- ALAC (Apple Lossless Audio Codec)

Lossy, compressed audio:

- MP3
- OGG Vorbis
- AAC (Advanced Audio Coding)

Loudness - dB SPL (not digital)

The most common use of dB is decibel of sound pressure level (dB SPL)

Compared to a 60 dB sound: 70 dB sounds 2x as loud, 80 dB sounds 4x as loud, 90 dB sounds 8x as loud and so on…

Here are some common reference points in audio:

- Threshold of Hearing (Quietest Sound): 0 dB SPL
- Normal Speech Level: 60 dB SPL
- Average Music Listening Level: 80 dB SPL
- Threshold of Pain (Extremely Loud): 140 dB SPL

Loudness - dBFS

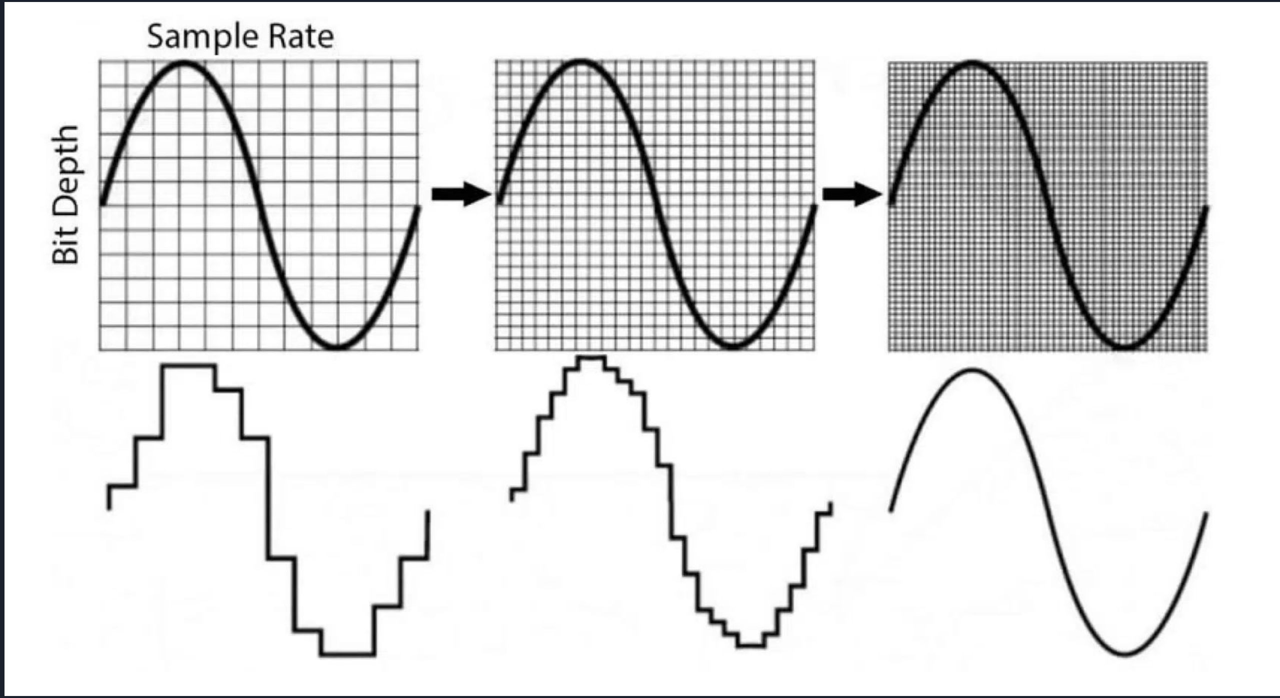
- Decibels relative to full scale
- Used in digital settings
- 0 dBFS is assigned to the maximum possible digital level
- All values quieter than that are negative values
- The number of possible values that can be represented is determined by the bit depth of the audio file

Bit Depth

- 16-bit: 65,536 values (CDs, compressed audio in Unity)
- 24-bit: 16,777,216 values (Blu-ray audio, uncompressed audio in Unity)
- 32-bit: 4,294,967,296 values

Sample Rate

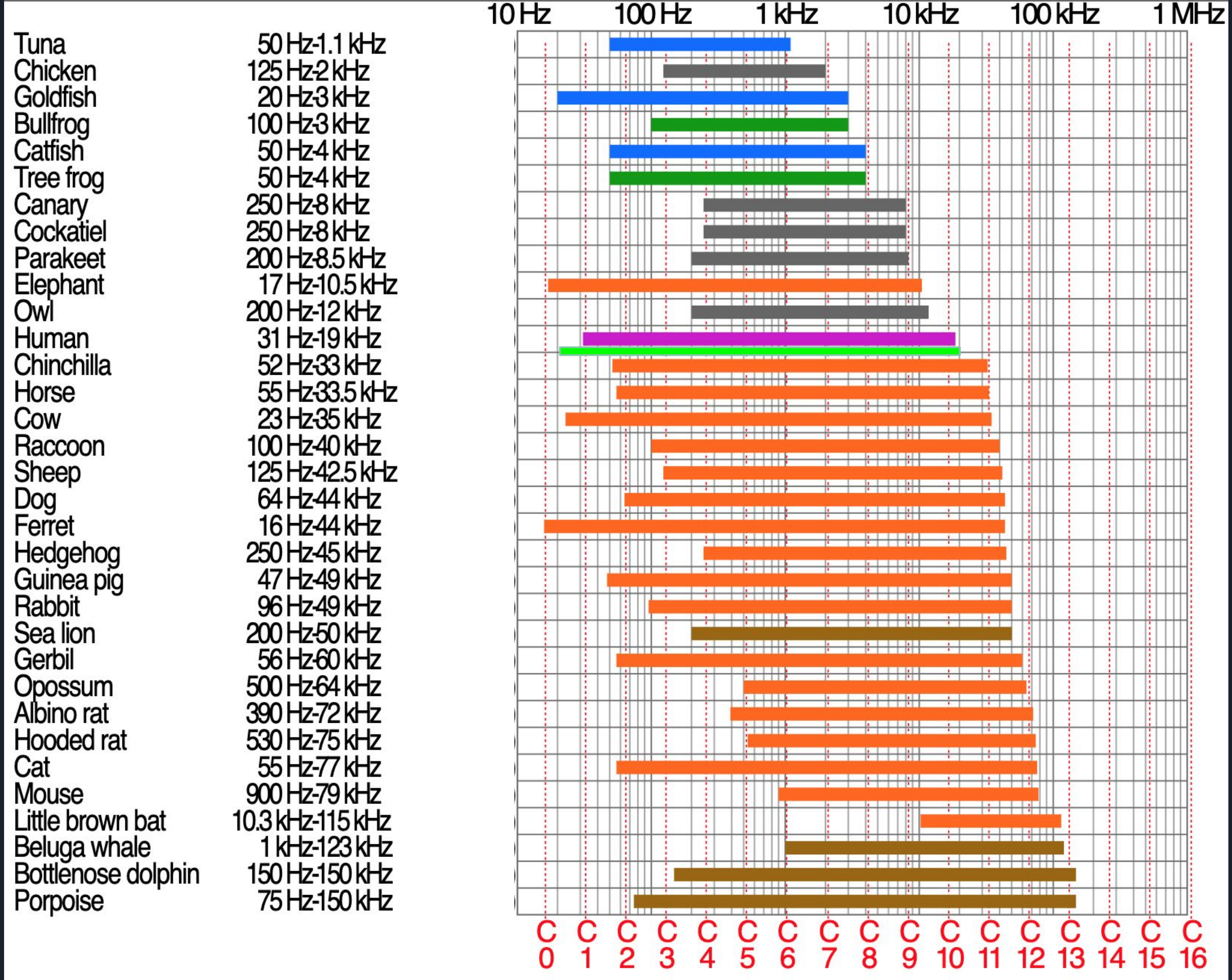
- 16,000 Hz
- 22,500 Hz
- 44,100 Hz (CDs)
- 48,000 Hz
- 96,000 Hz
- 128,000 Hz



source

Nyquist-Shannon Sampling Theorem

“The sample rate must be at least twice the highest frequency of the signal to avoid aliasing”


10 Hz
100 Hz
1 kHz
10 kHz
100 kHz
1 MHz
Tuna 50 Hz-1.1 kHz
Chicken 125 Hz-2 kHz
Goldfish 20 Hz-3 kHz
Bullfrog 100 Hz-3 kHz
Catfish 50 Hz-4 kHz
Tree frog 50 Hz-4 kHz
Canary 250 Hz-8 kHz
Cockatiel 250 Hz-8 kHz
Parakeet 200 Hz-8.5 kHz
Elephant 17 Hz-10.5 kHz
Owl 200 Hz-12 kHz
Human 31 Hz-19 kHz
Chinchilla 52 Hz-33 kHz
Horse 55 Hz-33.5 kHz
Cow 23 Hz-35 kHz
Raccoon 100 Hz-40 kHz
Sheep 125 Hz-42.5 kHz
Dog 64 Hz-44 kHz
Ferret 16 Hz-44 kHz
Hedgehog 250 Hz-45 kHz
Guinea pig 47 Hz-49 kHz
Rabbit 96 Hz-49 kHz
Sea lion 200 Hz-50 kHz
Gerbil 56 Hz-60 kHz
Opossum 500 Hz-64 kHz
Albino rat 390 Hz-72 kHz
Hooded rat 530 Hz-75 kHz
Cat 55 Hz-77 kHz
Mouse 900 Hz-79 kHz
Little brown bat 10.3 kHz-115 kHz
Beluga whale 1 kHz-123 kHz
Bottlenose dolphin 150 Hz-150 kHz
Porpoise 75 Hz-150 kHz
C 0
C 1
C 2
C 3
C 4
C 5
C 6
C 7
C 8
C 9
C 10
C 11
C 12
C 13
C 14
C 15
C 16

Calculating Filesize

Filesize = sample rate × bit depth × length (seconds) × number of channels

Filesize = 48,000 × 16 × 30 × 2 (stereo)

Filesize = 46,080,000 bits

Filesize = 5,760,000 bytes

Filesize = 5.76 MB (megabytes)

The Nintendo DS had a total RAM of 4 MB…

Audio in Video Games - RAM

Audio files are compressed and loaded into the RAM for fast access

An audio file can then be decompressed when a sound needs to be played. This costs the CPU a little bit of usage

The audio can be stored in RAM uncompressed and then instantly played as decompression is not needed. This costs the CPU nearly zero usage, but comes at the cost of using RAM

Studios will typically allocate a tiny amount of RAM to the sound developers

Audio in Video Games - Streaming

Audio files can be streamed instead. This means they are accessed from the disk (hard drive)

This can save using RAM

There is a slight delay when accessing (reading from the disk is slow)

Works great for soundtracks and music

Audio in Video Games - Optimisation

Use mono over stereo where possible

Compress with a lossy audio format

Apply Nyquist-Shannon theorem

Use uncompressed WAV, which is equivalent to Pulse-code modulation (PCM), to save on CPU usage at the cost of the RAM budget

Use an Adaptive differential pulse-code modulation (ADPCM), for a slightly smaller RAM usage with the same CPU usage