

Creative Computing II

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Winter 2010, tbc

Music File Formats

Recording quality

CD quality:

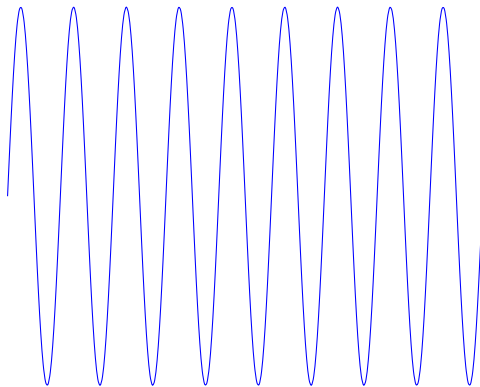
- ▶ amplitude samples at 44.1kHz (so *Nyquist frequency* is 22.05kHz);
- ▶ 16 bits per sample;
- ▶ two channels.

Recording quality:

- ▶ 88.2kHz – 176.4kHz
- ▶ more than 16 bits per sample
- ▶ usually more than two channels (one channel per transducer)

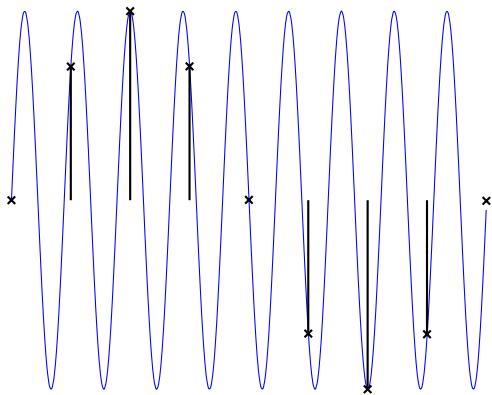
Music File Formats

Nyquist Frequency



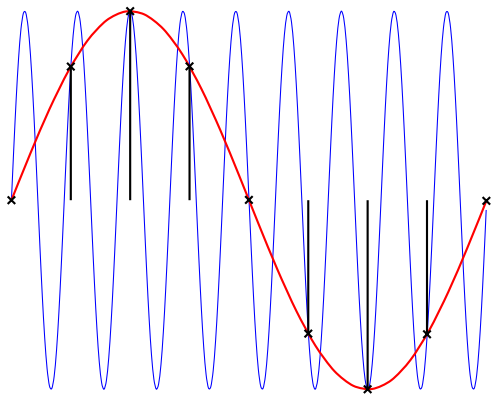
Music File Formats

Nyquist Frequency



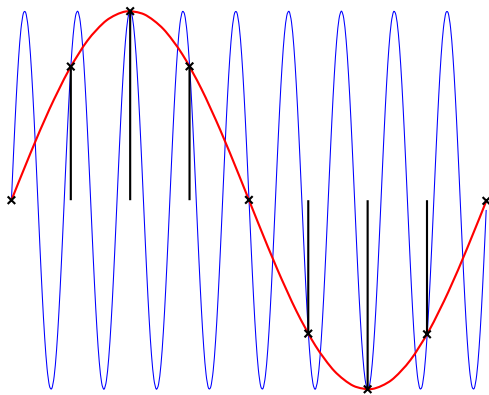
Music File Formats

Nyquist Frequency



Music File Formats

Nyquist Frequency



Higher frequency is *aliased* to the lower frequency. (all frequencies $f = |f_0 \pm nf_s|$ aliased together)

Music File Formats

'Lossless' Audio Formats

Advantages:

- ▶ fidelity;

Disadvantages:

- ▶ file size;

Examples:

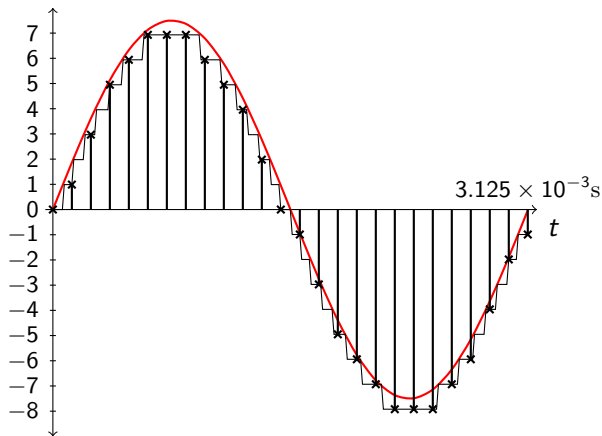
- ▶ Pulse-Coded Modulation (PCM, WAV);
- ▶ Free Lossless Audio Codec (FLAC);

Note: audio encoded in these formats can be of low quality or degraded with reference to a master copy.

Music File Formats

'Lossless' Audio Formats: PCM

Quantization and Sampling:



Music File Formats

'Lossless' Audio Formats: PCM

PCM in the wild: WAV files

- ▶ mono or stereo;
- ▶ 8 or 16 bits per sample;
- ▶ variable sample rate (typically 8kHz, 44.1kHz)
- ▶ (bitrate between 64kbps and 1.4112Mbps)

Music File Formats

'Lossless' Audio Formats: PCM

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File format:

- ▶ header information;
- ▶ sound data.

Music File Formats

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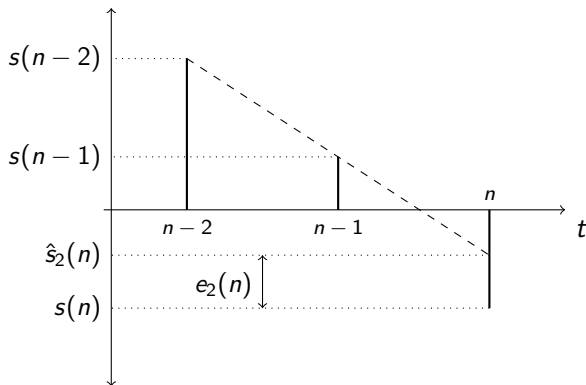
Octave support: `wavread`, `wavwrite`

Music File Formats

'Lossless' Audio Formats: FLAC

Free Lossless Audio Codec:

- ▶ lossless compression for audio (original PCM reconstructible);
- ▶ two main parts:
 - ▶ channel decorrelation;
 - ▶ predictive coding.



Music File Formats

Lossy Audio Compression

Advantages:

- ▶ small(er) file size;

Disadvantages:

- ▶ loss of fidelity;
- ▶ processing power needed to decode.

Examples:

- ▶ MPEG 1 Layer 3 (MP3)
- ▶ Advanced Audio Coding (AAC)
- ▶ Ogg Vorbis

Note: Ogg Vorbis is intended to be 'patent-free'.

Music File Formats

The Psychoacoustic Model

Masking:

- ▶ Simultaneous masking
 - ▶ $A \sin(\omega t) + \gamma A \sin((\omega + \epsilon)t)$
 - ▶ higher-frequency sound is 'masked'.
- ▶ Temporal masking
 - ▶ $\delta(t - \tau) + \delta(t - (\tau + \epsilon))$
 - ▶ second-occurring onset is 'masked'

Frequency response:

- ▶ Removal of 'irrelevant' frequencies
- ▶ Example: telephone transmission

Music File Formats

'Symbolic' formats

Examples:

- ▶ MIDI: Musical Instrument Digital Interface;
- ▶ Score-notation formats:
 - ▶ Lilypond;
 - ▶ MusicXML;
 - ▶ abc;
 - ▶ ... the list is endless.

Notes:

- ▶ MIDI is also used for performance;
- ▶ MusicXML is not a well-defined standard.

Music File Formats

MIDI Files

- ▶ binary format;
- ▶ events;
- ▶ 'note on' and 'note off' model
- ▶ NB: note on with 'velocity' 0 not the same as 'note off'
- ▶ different MIDI devices (and programs) interpret things in different ways.

Music File Formats

MIDI Files

Global attributes:

- ▶ file format, division, tracks

Cross-track attributes:

- ▶ tempo map, time signature

Track events:

- ▶ note on, note off
- ▶ effects: pitch bend, aftertouch
- ▶ meta messages: lyrics, text, key signature
- ▶ program change

Music File Formats

MIDI Files

General MIDI instruments (selected by program change messages):

- ▶ 1: Acoustic Grand Piano
- ▶ 5: Electric Piano 1
- ▶ 6: Electric Piano 2
- ▶ 34: Electric Bass (finger)
- ▶ 35: Electric Bass (pick)
- ▶ 50: String Ensemble 2
- ▶ 53: Choir Aahs
- ▶ 102: Goblins
- ▶ 123: Seashore
- ▶ 126: Helicopter
- ▶ (128 total)