Digital Audio

Issues to be covered (Over next few lectures):

- Digital Audio
  - Sampling Theorem
  - Digital Audio Signal Processing
  - Digital Audio Effects

Digital Audio Applications

Application of Digital Audio — Selected Examples

Music Production

- Hard Disk Recording
- Sound Synthesis
- Samplers
- Effects Processing

Video – Audio Important Element: Music and Effects

Web — Many uses on Web

- Spice up Web Pages
- Listen to Cds
- Listen to Web Radio

What is Sound?

Source — Generates Sound

- Air Pressure changes
- *Electrical* — Loud Speaker
- *Acoustic* — Direct Pressure Variations

Destination — Receives Sound

- *Electrical* — Microphone produces electric signal
- *Ears* — Responds to pressure **hear** sound (MPEG Audio — exploits this fact)




Back
Close

Digitising Sound

- **Microphone produces *analog* signal**
- Computer like discrete entities

Need to convert Analog-to-Digital — Specialised Hardware

Also known as *Sampling*

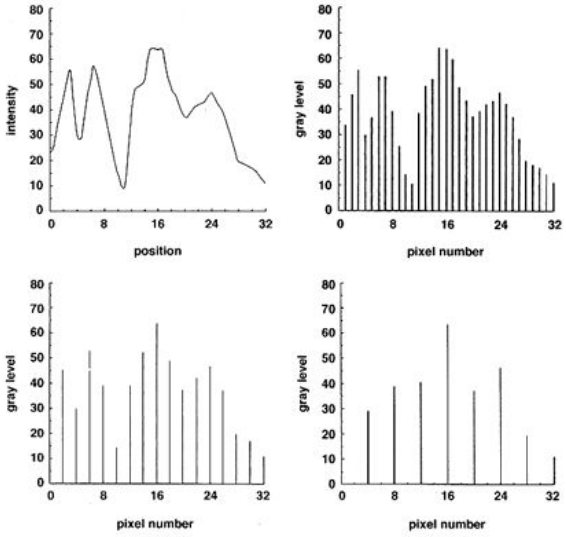


Back
Close

Digital Sampling

Sampling basically involves:

- Measuring the analog signal at regular discrete intervals
- Recording the value at these points



Computer Manipulation of Sound

Writing Digital Signal Processing routines range from being trivial to highly complex:

- Volume
- Cross-Fading
- Looping
- Echo/Reverb/Delay
- Filtering
- Signal Analysis




Back
Close

Sound Demos

- Volume
- Cross-Fading
- Looping
- Echo/Reverb/Delay
- Filtering




Back
Close

Sample Rates and Bit Size

How do we store each sample value (*Quantisation*)?

8 Bit Value (0-255)

16 Bit Value (Integer) (0-65535)

How many Samples to take?

11.025 KHz — Speech (Telephone 8 KHz)

22.05 KHz — Low Grade Audio
(WWW Audio, AM Radio)

44.1 KHz — CD Quality

Nyquist's Sampling Theorem

Sampling Frequency is Very Important in order to accurately reproduce a digital version of an Analog Waveform

Nyquist's Theorem:

The Sampling frequency for a signal must be **at least** twice the highest frequency component in the signal.



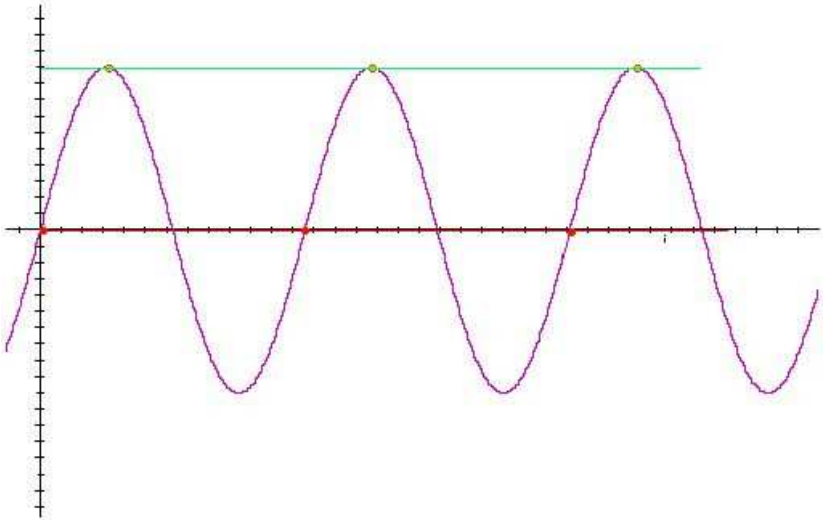



Figure 1: Sampling at Signal Frequency

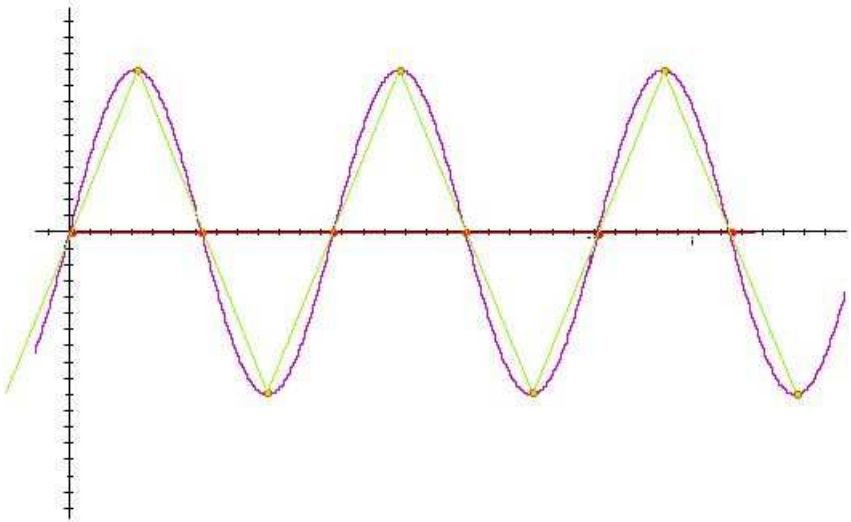


Figure 2: Sampling at Twice Nyquist Frequency

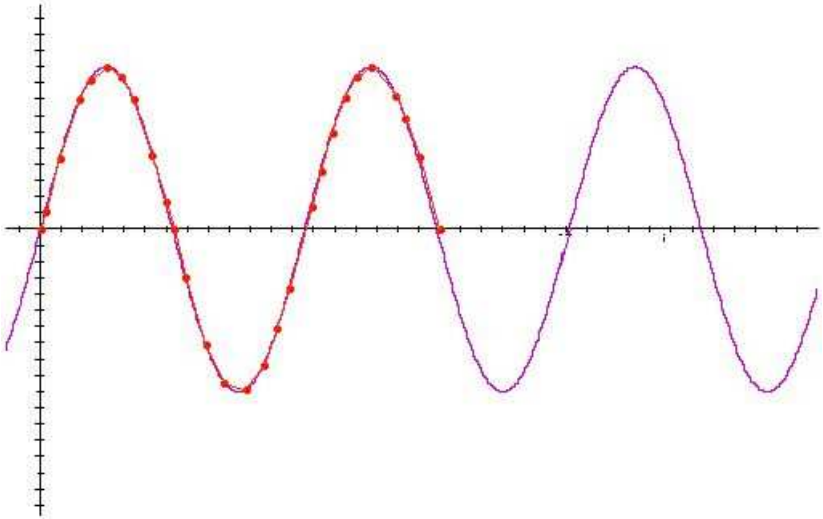


Figure 3: Sampling at above Nyquist Frequency

Implications of Sample Rate and Bit Size

Affects Quality of Audio

- Ears do not respond to sound in a linear fashion ((more later (MPEG Audio))
- Decibel (**dB**) a logarithmic measurement of sound
- 16-Bit has a signal-to-noise ratio of 98 dB — virtually inaudible
- 8-bit has a signal-to-noise ratio of 50 dB
- Therefore, 8-bit is roughly 8 times as noisy
  - 6 dB increment is twice as loud
- Click Here to Hear Sound Examples




Implications of Sample Rate and Bit Size (cont)

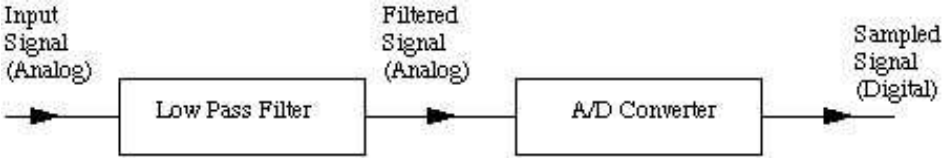
Affects Size of Data

File Type	*44.1 KHz*	*22.05 KHz*	*11.025 KHz*
16 Bit Stereo	10.1 Mb	5.05 Mb	2.52 Mb
16 Bit Mono	5.05 Mb	2.52 Mb	1.26 Mb
8 Bit Mono	2.52 Mb	1.26 Mb	630 Kb

Figure 4: Memory Required for 1 Minute of Digital Audio


Practical Implications of Nyquist Sampling Theory

- Must (low pass) filter signal before sampling:



- Otherwise strange artifacts from high frequency signals appear.

Why are CD Sample Rates 44.1 KHz?




Why are CD Sample Rates 44.1 KHz?

Upper range of human hearing is around 20-22 KHz — Apply Nyquist Theorem