MTE 1001

Fundamentals of Sound Synthesis

Topic Areas:

Digital Signals

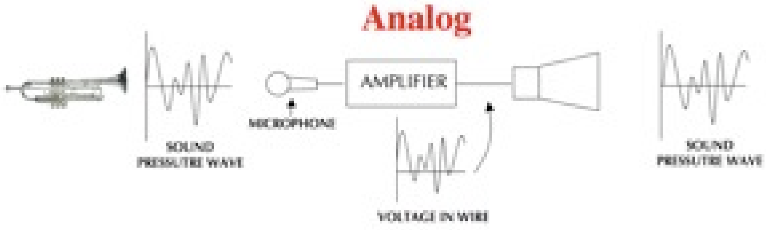
Readings:

(Previously, Chapt 3, pp. 87-90
Chapt. 4, pp 139-146)

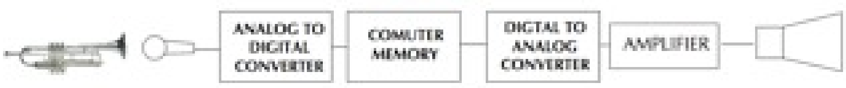
New: Chapt 1, pp 22-32

Analog vs. Digital

Analog

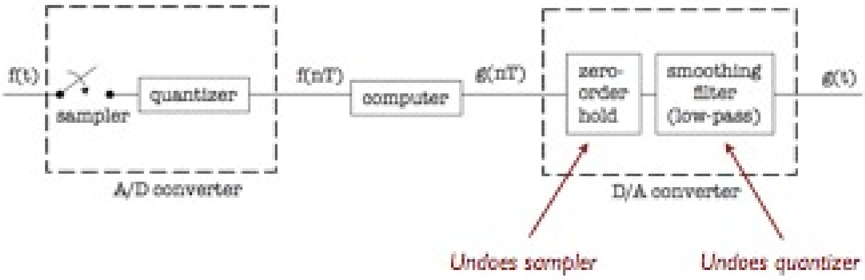


Digital

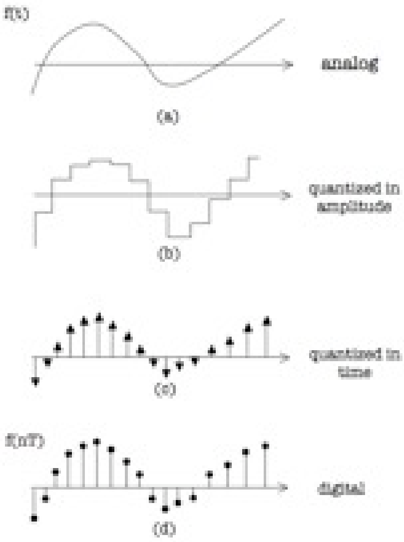


Idealized Model of Sampling and Reconstruction

A/D & D/A converters



Sampling and Signal Graphics



Graphic representation of types of signals:

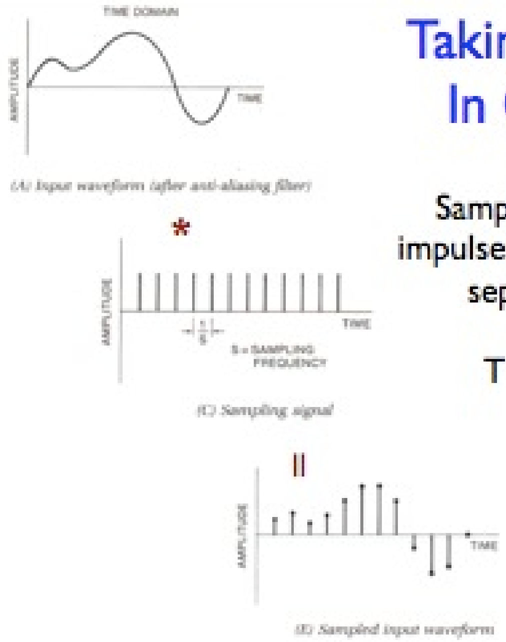
a) analog signal

b) quantized signal
(continuous time)

c) sampled data signal

d) digital signal

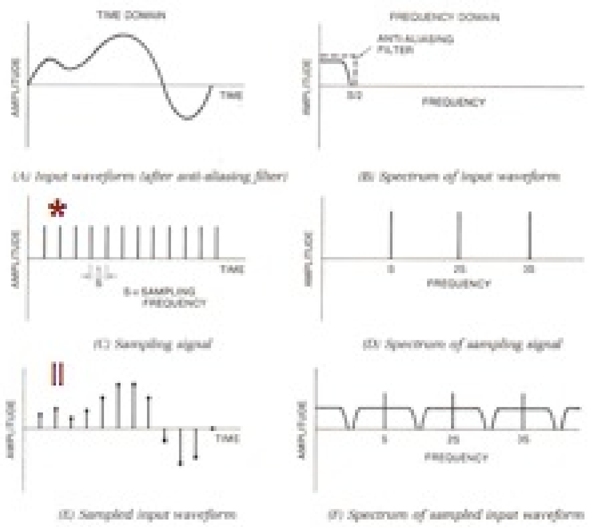
Taking Sampling In One Step



Sampling signal is a series of impulses at the **sampling rate** separated by T seconds
where
T = 1.0/samplingRate

Taking Sampling In One Step

Time Domain & Frequency Domain



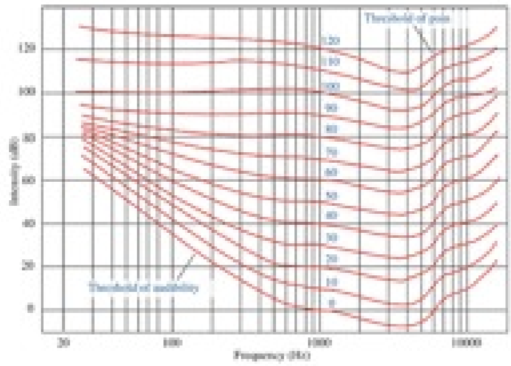
Fidelity

depends on:

- Sampling Rate
- Bit Depth
- (Encoding Scheme)

Human Hearing

20 - 20,000 Hz



Sampling Rate

Sampling Theorem:

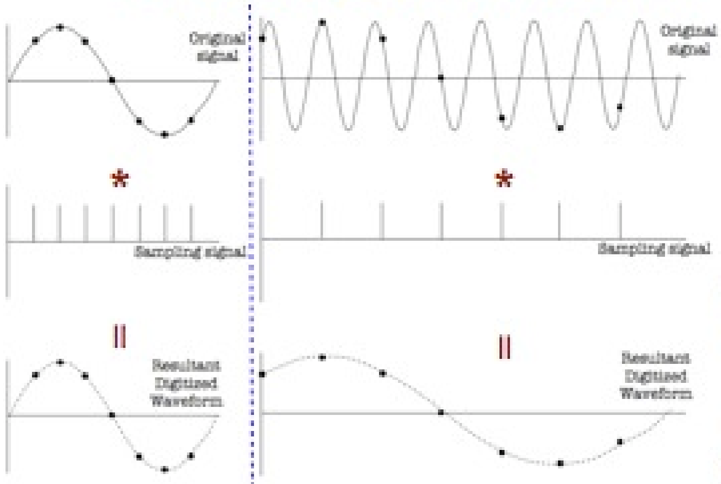
Must sample at a frequency twice as high as the highest sinusoidal component.

A consequence of the Sampling Theorem is that the highest frequency reproduced through a D/A converter is one half of its sampling rate.

Typical rates:	Highest freq.:	Fidelity:
8 K	4 K	dark, dull
11 K	5.5 K	↑
22 K	11 K	
44.1 K	22 K	↓
48 K	24 K	bright/clean

Why the Sampling Theorem?

Foldover Error: Time Domain



Foldover error is also called ***aliasing***

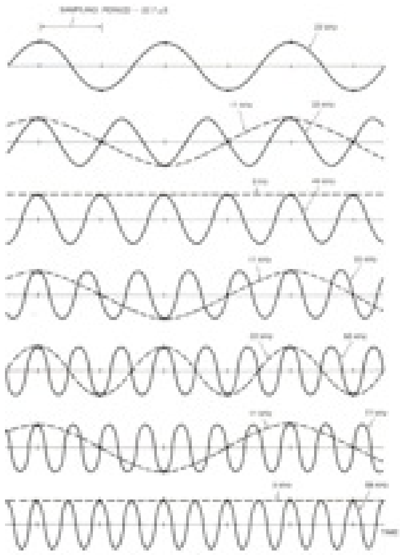
Why the Sampling Theorem?

Foldover Error

If the original signal is *undersampled*, the frequency of the resultant waveform is

SR - f

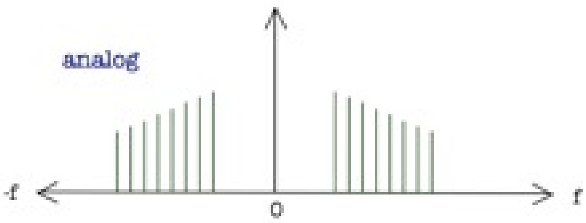
With a SR of 44100, attempting to create a tone of 30,000 Hz would result in an alias of 44100 - 30000 = 14100!



Why the Sampling Theorem?

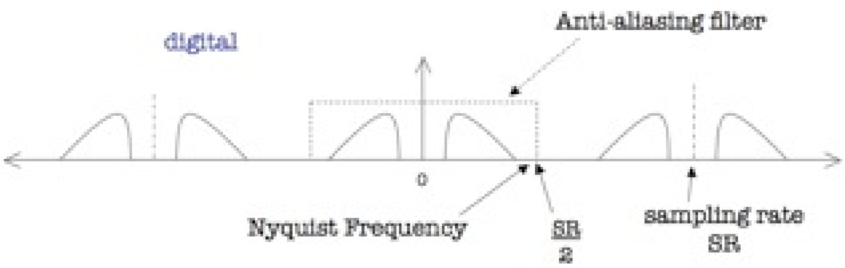
Foldover Error: Frequency Domain

First:
Positive and Negative Frequency



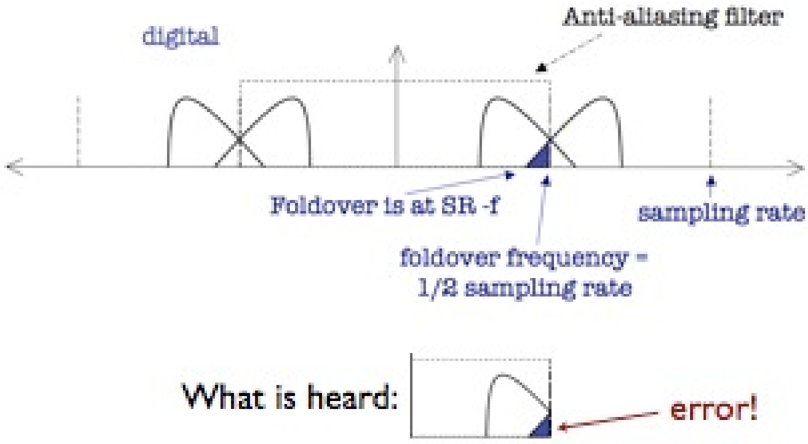
Why the Sampling Theorem?

Foldover Error: Frequency Domain



Why the Sampling Theorem?

Foldover Error: Frequency Domain



Sampling Theorem

Low sampling rates produce low fidelity.

And, if we are not careful, foldover error can create very audible distortion.

This is not a problem for recording any more, because A/D converts always have anti-aliasing filters, but we still have to be careful to avoid foldover in synthesis.

Next Topic: Digital Signals continued