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College of Science

Intelligent Medical System Department

University of Information Technology and Communications

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Lecture 5- Sampling and Recording

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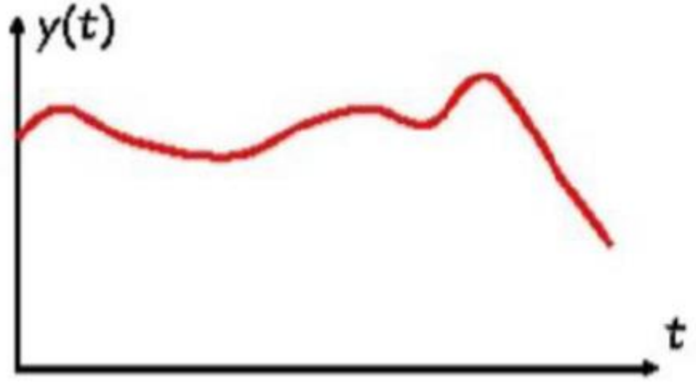
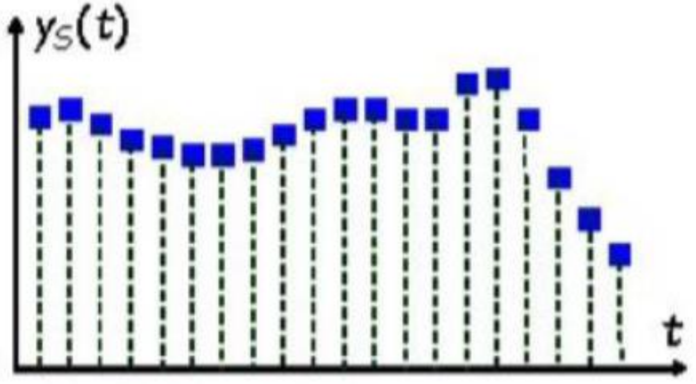
Sampling and Recording

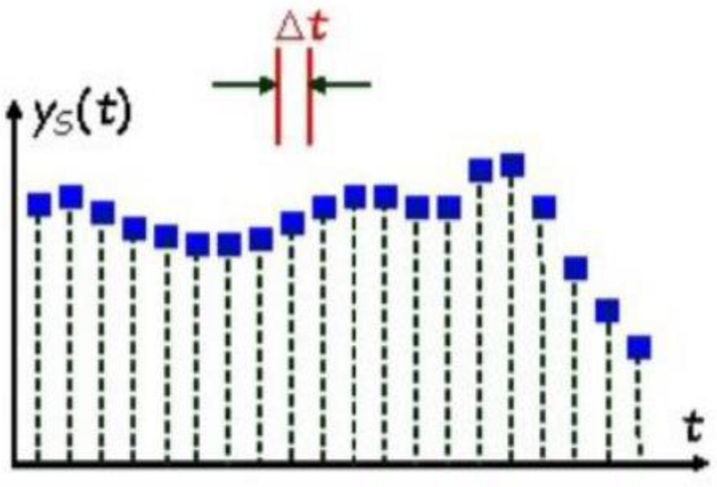
When perform a measurement . . . a *transducer* converts the *measurand* into an electrical signal ... and this signal is "*sampled*" using a digital computer

We normally record a continuous signal *y(t)* by a set of samples $y_5(t)$ at discrete intervals of time Δt





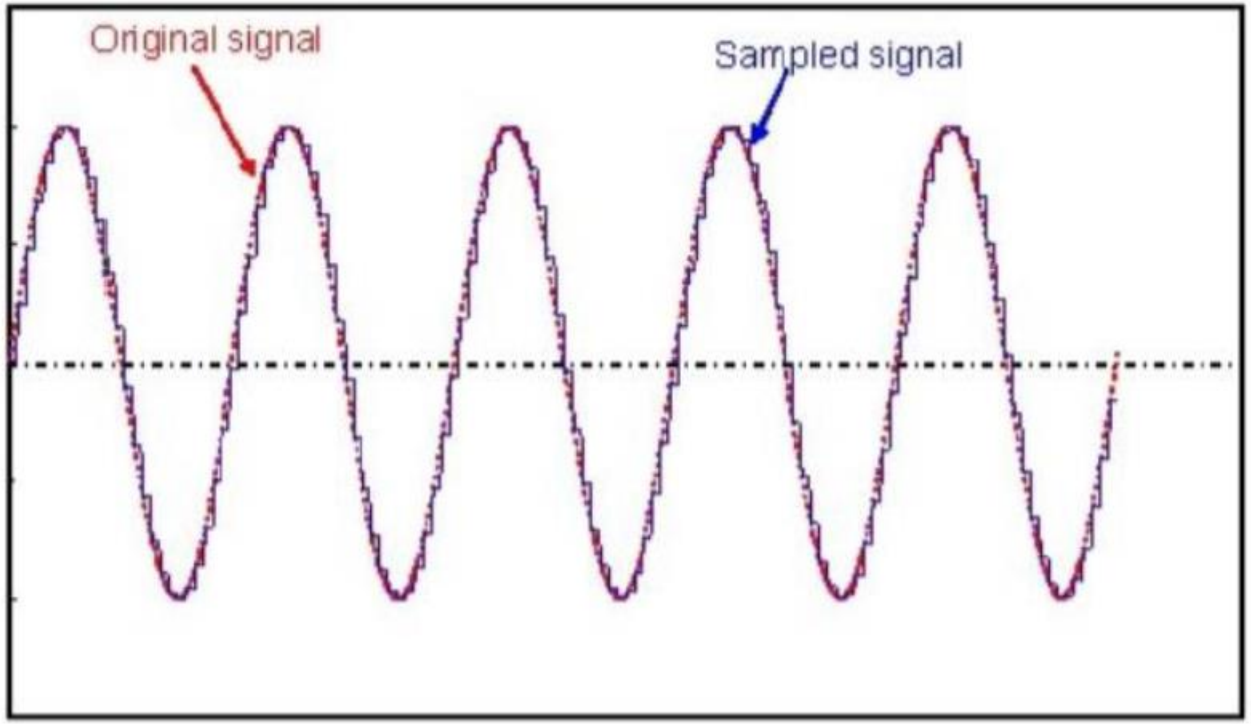
Sampling Frequency



$$f_s = \frac{1}{\Delta t}$$

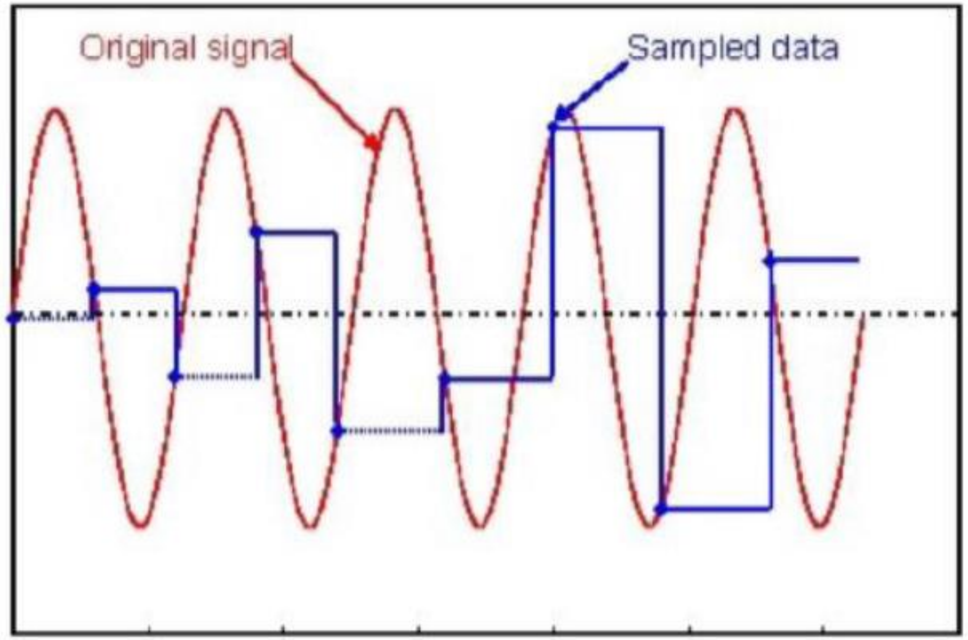
The number of samples recorded each second is defined as the sampling frequency, f_s.

Resemble Sampling Data



If a signal is sampled and recorded relative rapidly, the sampled data will closely resemble the original signal.

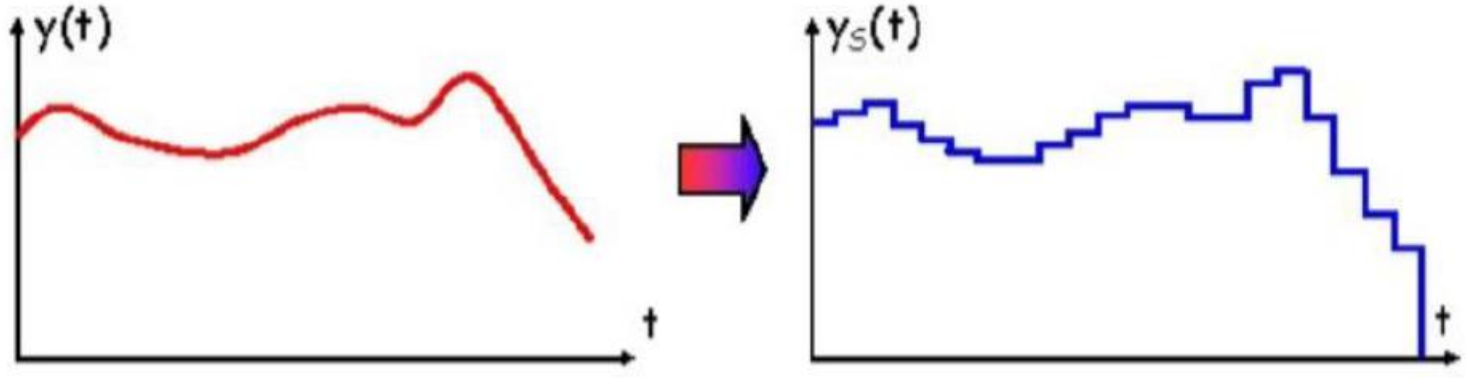
Under Sampling of Test Data



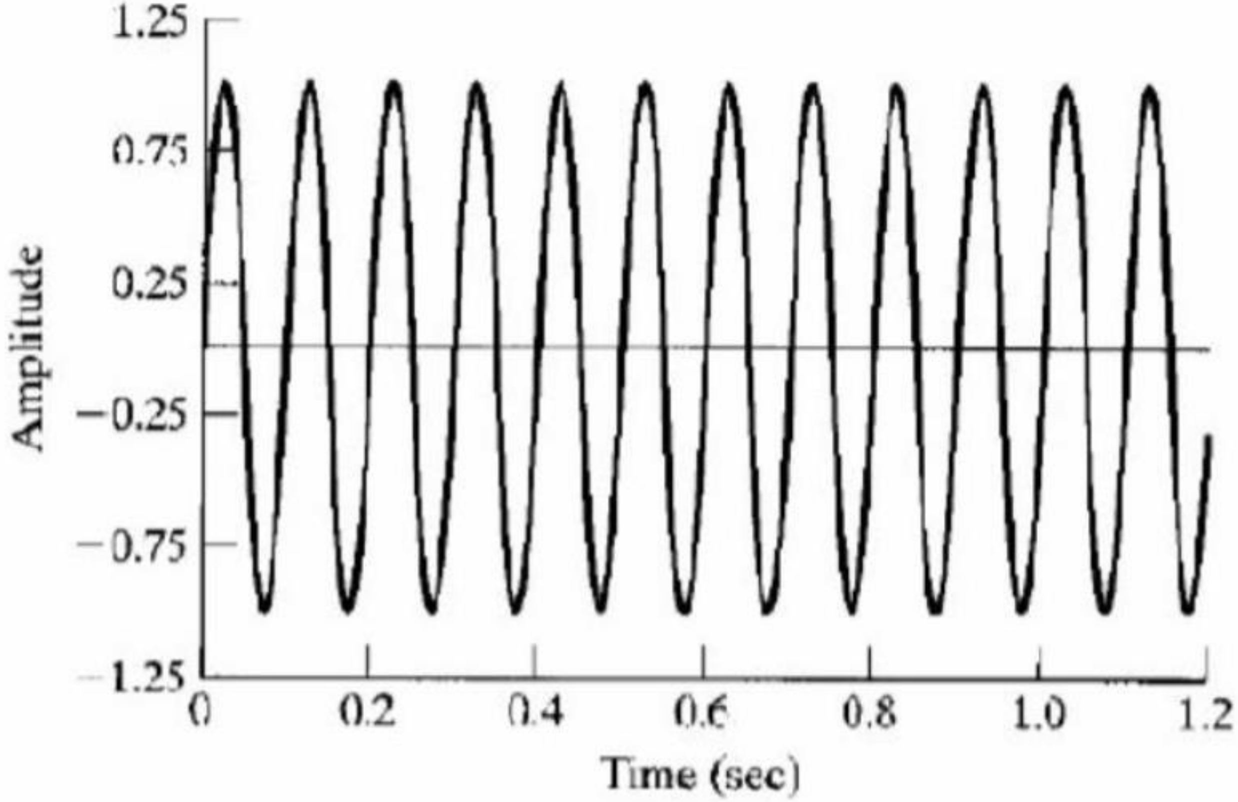
If we sampled too slowly, a recorded data will present a distortion from the original signal. Such distortion will introduce some measurement errors.

Sampling and Hold

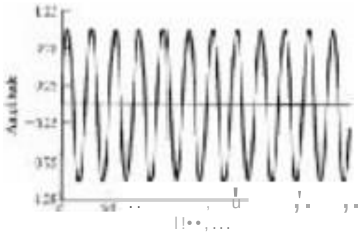
- Almost any analog to digital converter will have some form of voltage "hold" before sampling. A sampling and hold unit is used to hold each sample value until the next pulse occurs. The sampling and hold unit is necessary because the A/D converter requires a finite amount of time.

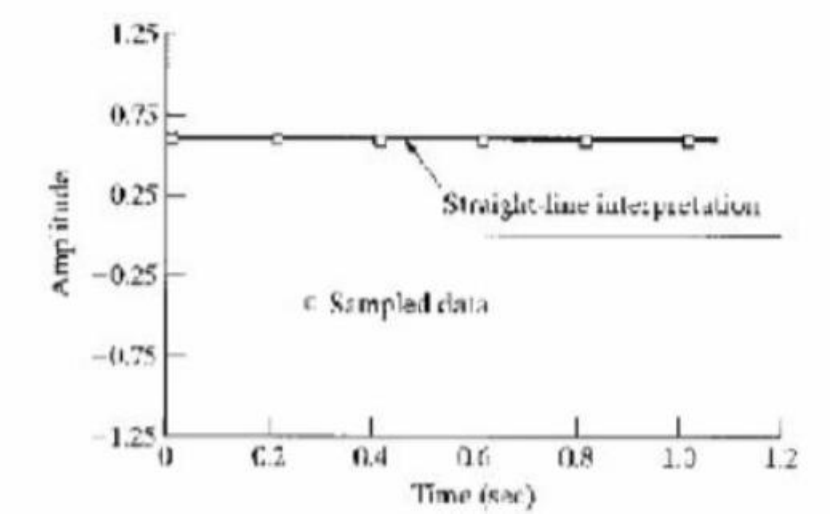


A 10 Hz Sine Wave Signal



Sampling Rate - 5 Hz

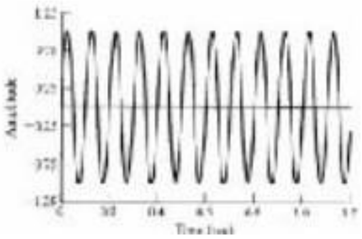


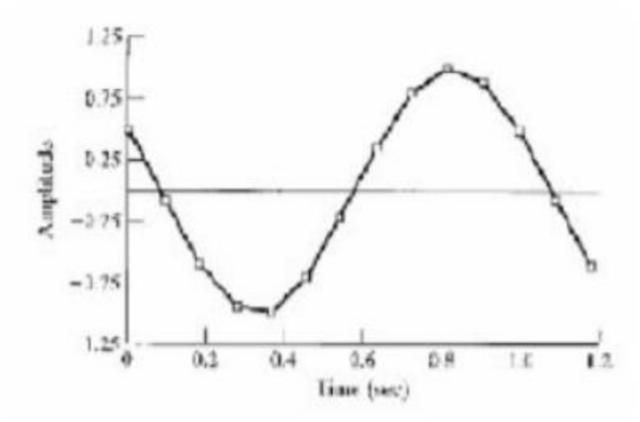


- One could conclude that the sampled signal hns a constant value

- The amplitud e of the sampled datn is also mislead ing
- This hehuvior uccurs ifhe wuve is Sltrnf)led ul any rate thaf is an integer fraction of the base ft·equency

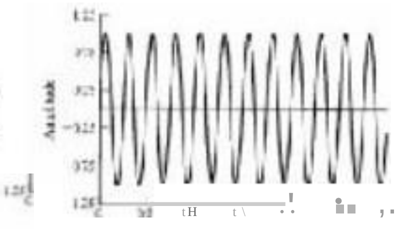
Sampling Rate ~ 11 Hz

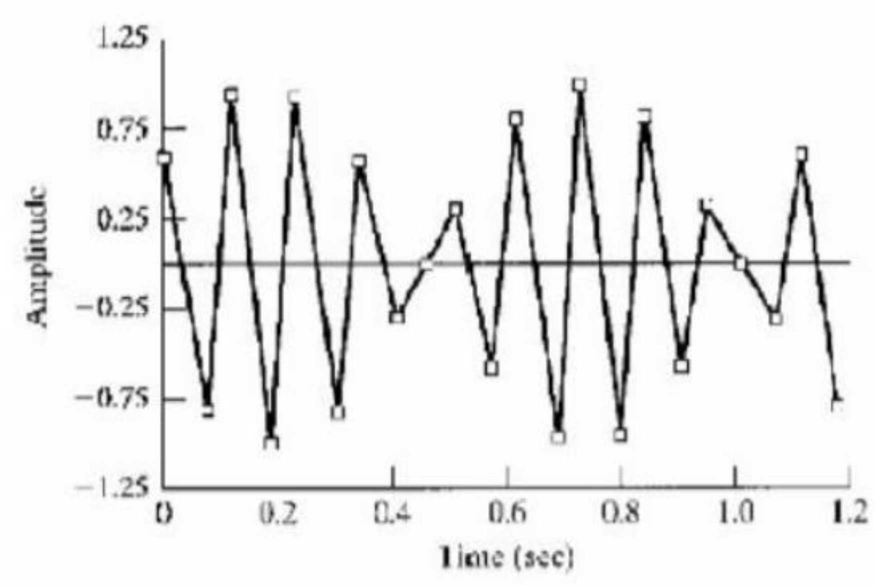




- The signal appeurs to be a sine wave
- One cycle appear in the time that 10 cycles occurred for the sampled data
- The frequency I Hz is the difference hetween the sampling frequency and sampled rote

Sampling Rate ~ 18 Hz

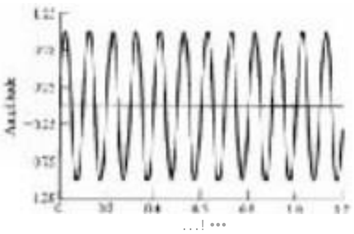


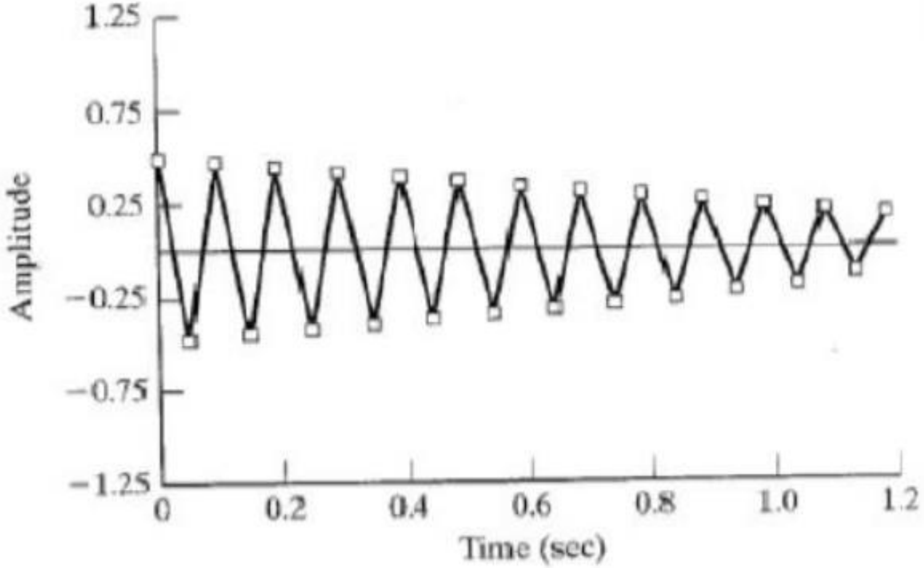


At a sampling frequency of 18 Hz, the reconstructed sine wave appears to be of 8 Hz sine wave. That is, the frequency of the sine wave reconstructed from the sampled data is still different from that of the original signal.

These incorrect frequencies that appear in the output data range are known as *alias* frequencies or *aliases.* The alias frequencies are false frequencies that appear in the output data, that are slmply artifacts of the sampiing process, and that do not (in any matter) occur in the original data.

Sampling Rate ~ 20.1 Hz





- Now, consider the reconstruction of the original signal based on the sampling rate of 20.1 Hz.
- The above figure shows the signal reconstructed from the data sampled at a frequency of 20.1 Hz. The reconstructed wave has a frequency of 10 Hz, which Is the same frequency as the original signal. However, the amplitude of the reconstructed wave Is lower than the original one.

Example 1:Find the Sampling frequency of : $\sin 100\pi t + \cos 200\pi t$

Solution :

$X(t) = \sin 100\pi t + \cos 200\pi t$

$\omega = 2\pi f$

$\omega 1 = 100\pi$

$2\pi f = 100\pi$

$f1 = 50$ Hz

Example 1: cont.

$X(t) = \sin 100\pi t + \cos 200\pi t$

$\omega = 2\pi f$

$\omega 2 = 200\pi$

$2\pi f = 200\pi$

$f2 = 100$ Hz

Example 1: cont.

f_m= max (f_1 , f_2) = max (50 , 100) = 100 Hz

f_S= 2 f_m = 2 x 100 Hz = 200 Hz

Example 2 : if a signal having frequency components 0-10 Hz is sampled at 10 Hz. Is there aliasing effect on the signal or not ?

- f_S= 10 Hz
- f_m= (maximum frequency component in message = 10 Hz

- f_S= f_m

- The signal is highly aliased