



جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

Al-Mustaqbal University College of Science



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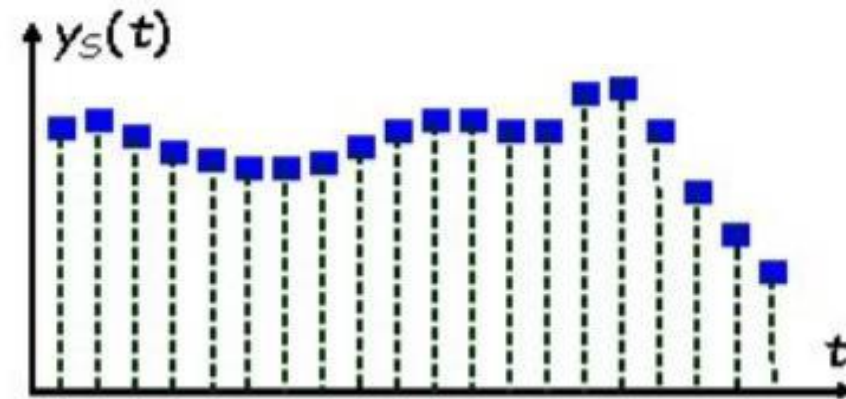
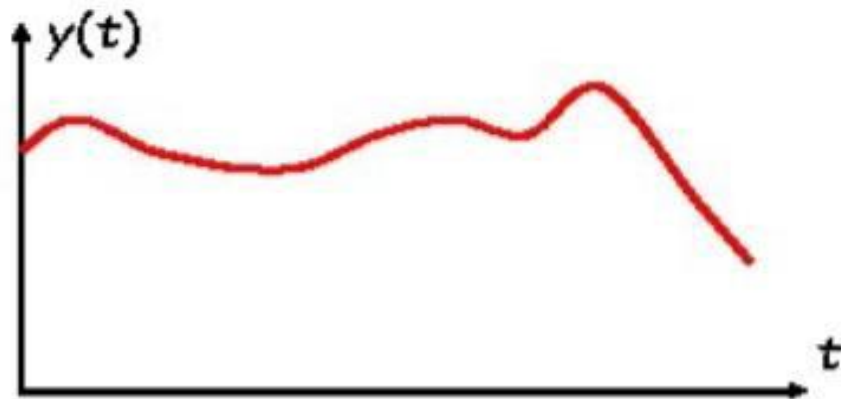
قسم الانظمة الطبية
الذكائية

Lecture 6- Sampling and Recording
Asst. Prof. Dr. Mehdi Ebady Manaa

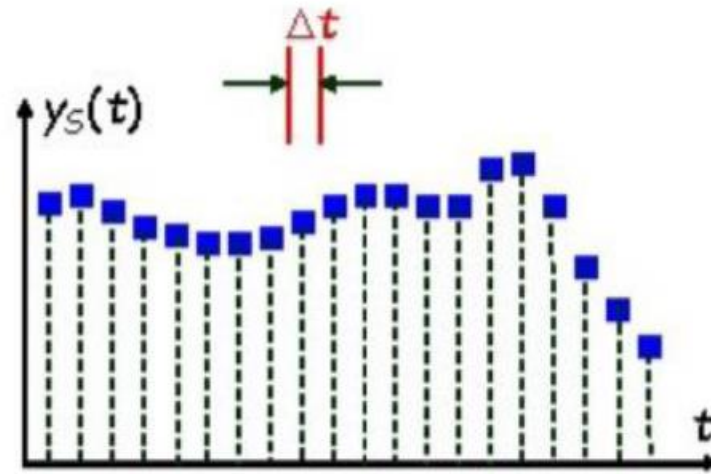
Sampling and Recording

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 $y_s(t)$ at discrete intervals of time Δt .



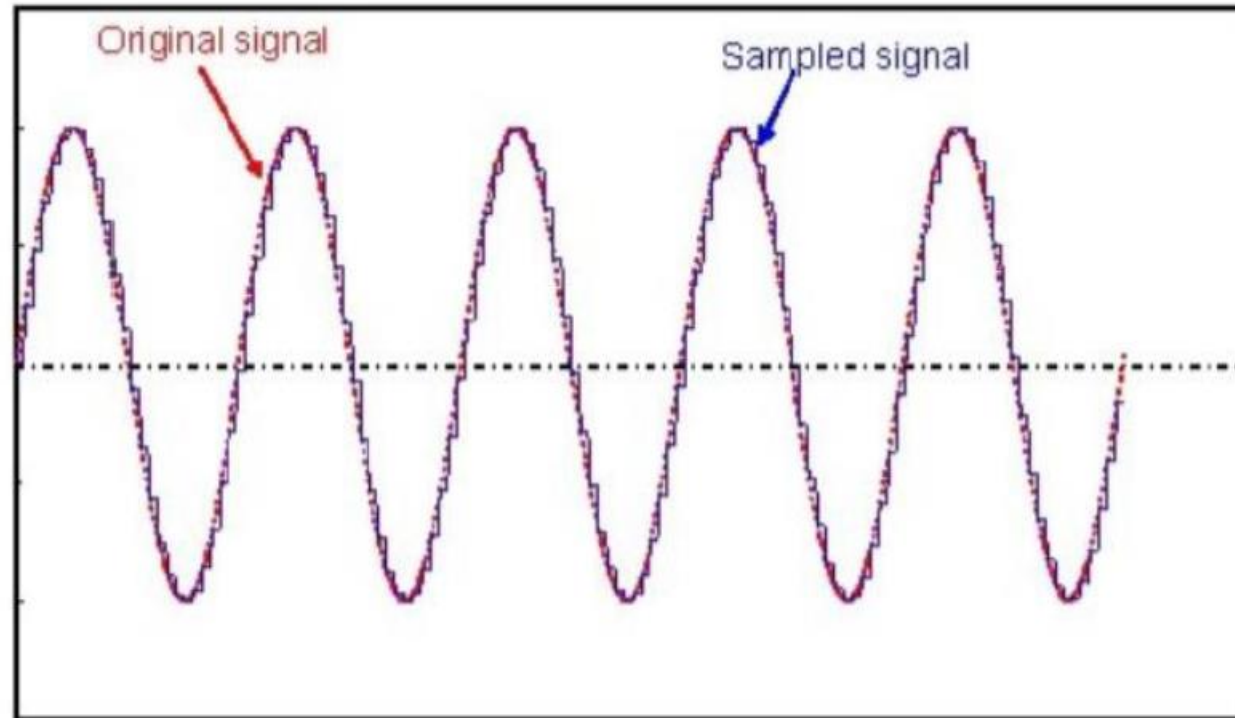
Sampling Frequency



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

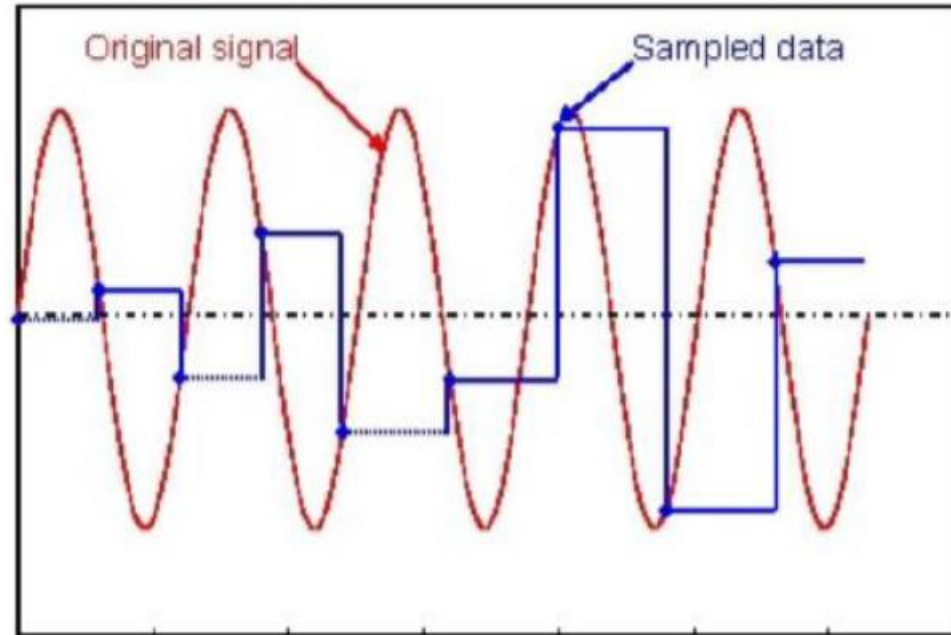
The number of samples recorded each second is defined as the sampling frequency, f_s .

Resemble Sampling Data



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

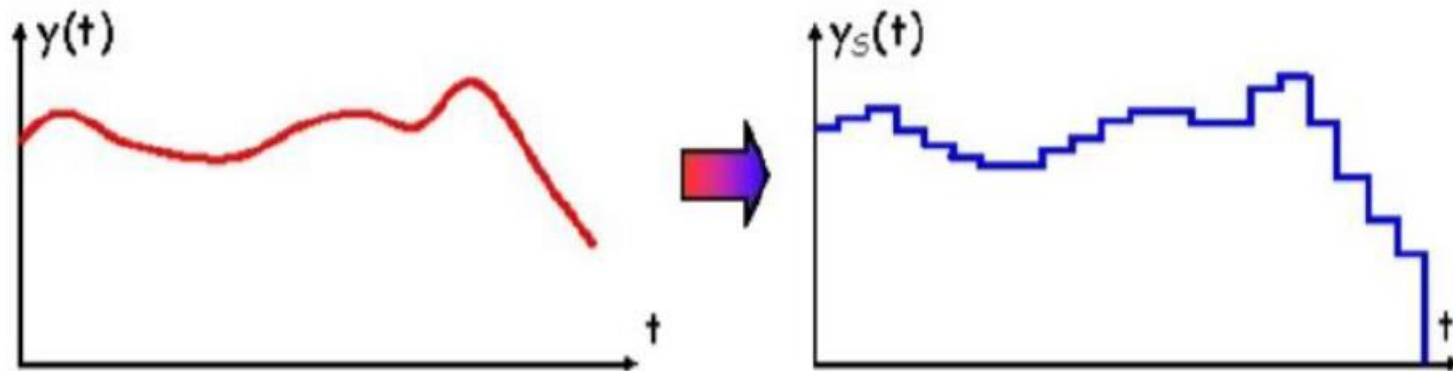
Under Sampling of Test Data



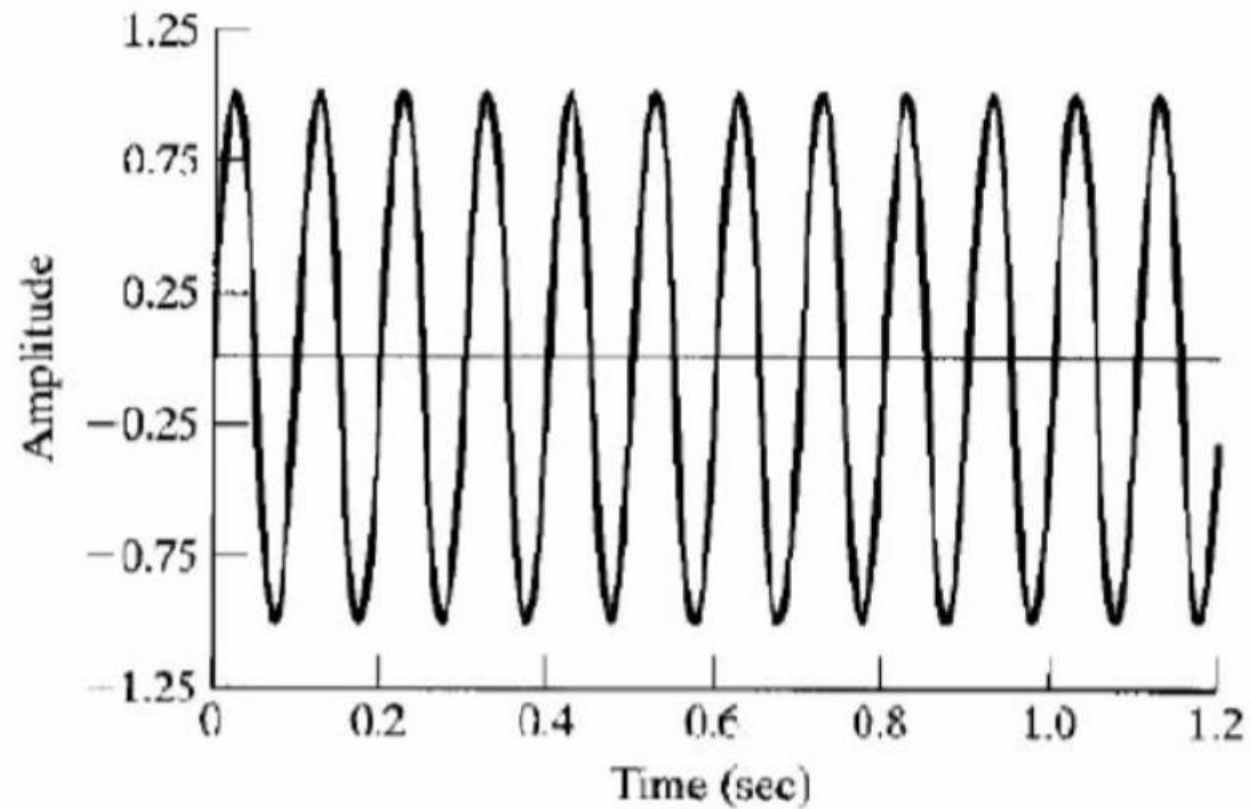
If we sampled too slowly, a recorded data will present a distortion from the original signal. Such distortion will introduce some measurement errors.

Sampling and Hold

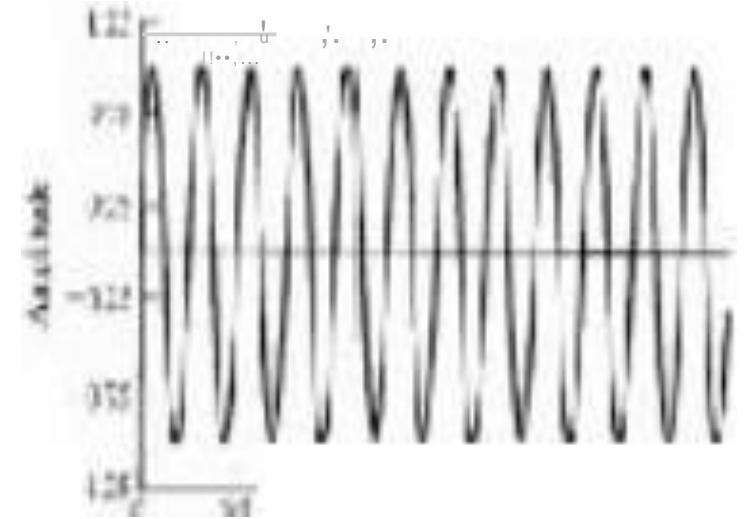
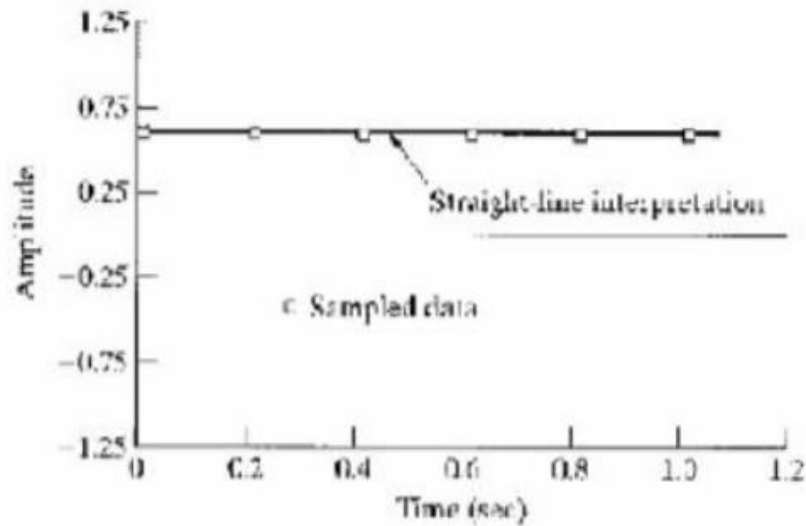
- Almost any analog to digital converter will have some form of voltage "hold" before sampling. A sampling and hold unit is used to hold each sample value until the next pulse occurs. The sampling and hold unit is necessary because the A/D converter requires a finite amount of time.



A 10 Hz Sine Wave Signal

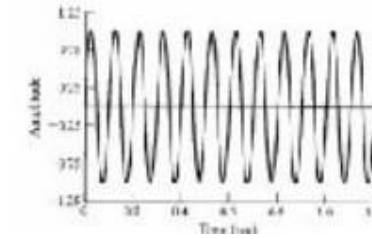
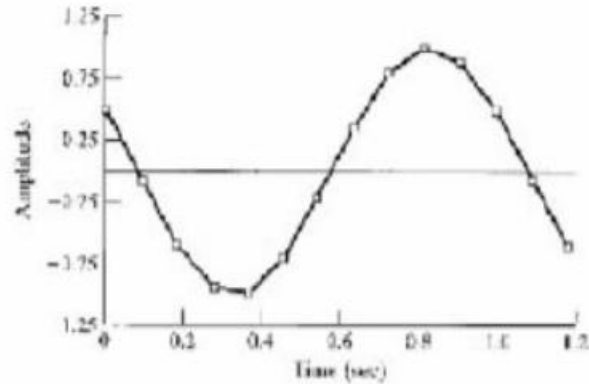


Sampling Rate - 5 Hz



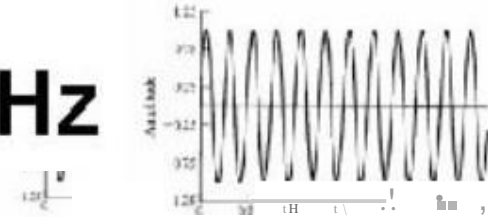
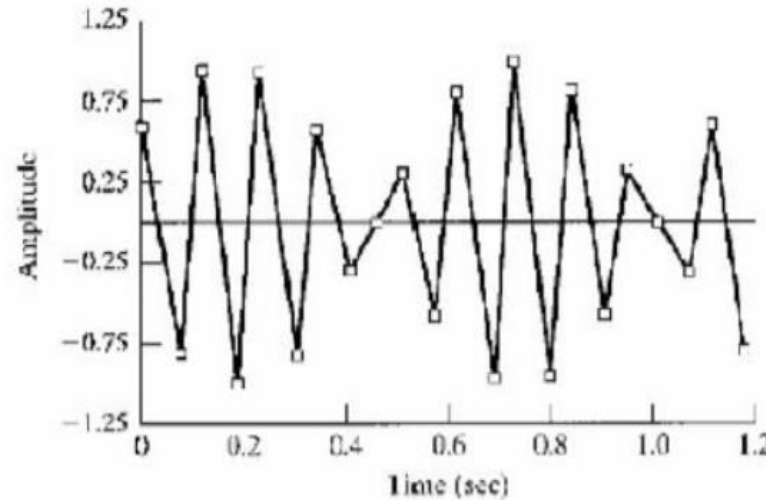
- One could conclude that the sampled signal has a constant value
- The amplitude of the sampled data is also misleading
- This behavior occurs if the wave is sampled at any rate that is an integer fraction of the base frequency

Sampling Rate ~ 11 Hz



- The signal appears to be a sine wave
- One cycle appears in the time that 10 cycles occurred for the original signal
- The frequency 1 Hz is the difference between the sampling frequency and sampled rate

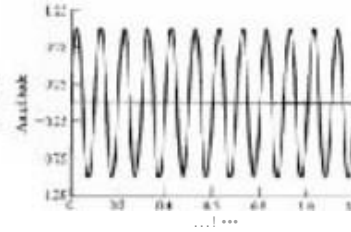
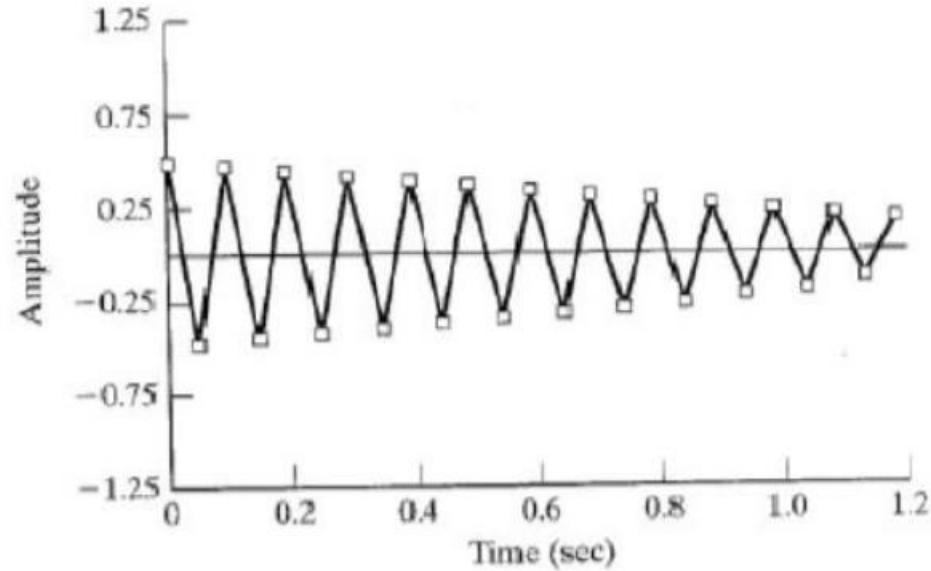
Sampling Rate ~ 18 Hz



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 simply artifacts of the sampling 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 :

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

$$\omega = 2 \pi f$$

$$\omega_1 = 100 \pi$$

$$2\pi f = 100 \pi$$

$$f_1 = 50 \text{ Hz}$$

Example 1: cont.

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

$$\omega = 2\pi f$$

$$\omega_2 = 200\pi$$

$$2\pi f = 200\pi$$

$$f_2 = 100 \text{ Hz}$$

Example 1: cont.

$$f_m = \max (f_1 , f_2) = \max (50 , 100) = 100 \text{ Hz}$$

$$f_s = 2 f_m = 2 \times 100 \text{ Hz} = 200 \text{ Hz}$$

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 ?

- $f_s = 10 \text{ Hz}$
- $f_m =$ (maximum frequency component in message = 10 Hz

- $f_s = f_m$

- The signal is highly aliased

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Thank You