Dr. Montadar Abas Taher 2019-2020

Lecture #1.1 Introduction

Signals and systems (COE202 - 3-2-1-2)

In this course we will study

1) signals 2) systems 3) classification of signals
4) Basic signal types 5) fundamental signals
6) System properties 7) Fourier series and transform
8) filters (analogue) 9) Hilbert transform.

1) Signals involves the definition of signals, fundamental or frequently used functions in communication systems, basic operations on signals, and signals measures.

2) Systems will be defined and how to deal with systems, the properties of the systems also will be given.

3) signals classification: According to certain parameters signals will be classified.

4) Fourier analysis includes Fourier series, triganometric, compact, and exponential forms. Furthermore, fourier transform will be given in detailes with the necessary theorems related to fourier transform.

5) Filters: Analogue filters, Low pass filter (LPF), high pass filter (HPF), and band pass filter (BPF) will be designed first and second order.

6) Hilbert transform is usefull for the communication systems, it will be introduced to make use of it in the linear moduation systems in the next semester.

Signals: the history of gathered information during unit time or area, etc. For instance, current flow in a capacitor or any other device during time. Electrons distribution in unit area, Velocity of car, these are signals and can be expressed mathematically in closed form.

signals can be written as functions as $x(t)$, $f(t)$, $g(t)$, or $m(t)$, where t is the independent variable which represents time.

Systems:- signals are the output of systems, or a system excepts input signal to produce another signal. For example, the Keyboard of the computer accepts your Key pressing then the output of the system is the Key you just pressed which will be displayed on the screen. Another example is the C++ program where you provide inputs to the program to give you the results, which are the output of the system.

another example of system is the satellite receiver in your home. The satellite receiver receives the signal from the satellite as electromagnetic waves, the receiver will converts the waves to the pictures and sound you follow up.

Classification of signals:-

signals can be classified as:

i) Continuous and Discrete signals,
ii) Analogue and Digital signals,
iii) Real and Complex signals,
iv) Deterministic and Random signals,
v) Even and Odd signals,
vi) Periodic and Aperiodic signals, and
vii) Energy and power signals.

i) Continuous and Discrete Time Signals :-

signal depends on the independent variable. For example, the signal $x(t)$, the signal here expressed as x which is the dependent variable while t is the independent variable. If the independent variable t is defined at any instant then t is called continuous variable, hence $x(t)$ is a continuous time signal.

On the other hand, if the independent variable t is defined at specific points

$$t = nT_s \quad \text{———} (1)$$

where n is an integer number, $n = 0, \mp 1, \mp 2, \ldots$ and T_s is the sampling period, then t is discrete and not continuous, therefore x is written as $x[n]$ which is discrete time signal.

In general: continuous time signal represented as $x(t)$

Discrete time signal is, using equation (1)

$$x(nT_s) = x(0), x(1), x(2) \text{---}$$

or

$$x[n] = x[0], x[1], x[2], \text{---}$$

in other words, the discrete time signal is a sequence of numbers.

Ex.1 $x[n] = [\underline{4}, 3, 2, -1, 13, 0, 8, 10]$

$x[0] = 4$, $x[1] = 3$, $x[2] = 2$

$x[3] = -1$, $x[4] = 13$, $x[5] = 0$

$x[6] = 8$, $x[7] = 10$.

Ex.2 $g[n] = [4, 0, 2, 1, \underline{2}, 3, 2, 2, 8]$

$$\begin{array}{cccccccccc} & -4 & -3 & -2 & -1 & 0 & 1 & 2 & 3 & 4 \quad 5 \end{array}$$

$g[0] = 2$, $g[1] = 3$, $g[2] = 2$, $g[3] = 2$, $g[4] = 2$

$g[5] = 8$.

$g[-1] = 1$, $g[-2] = 2$, $g[-3] = 0$, $g[-4] = -4$.

Ex.3 Add the two discrete time signals

$$x[n] = [4, 4, 4, 4, \underline{4}, 4, 4, 4, 4]$$

$$y[n] = [8, 5, 7, 1, \underline{1}, 1, 2, -4, -8]$$

Solution

$$x[n] + y[n] = z[n]$$

$$z[n] = \begin{array}{l} x[n] \rightarrow \\ \\ y[n] \rightarrow \end{array} \left[\begin{array}{ccccccccc} 4, & 4, & 4, & 4, & \underline{4}, & 4, & 4, & 4, & 4 \\ & & & & + & & & & \\ 8, & 5, & 7, & 1, & \underline{1}, & 1, & 2, & -4, & -8 \end{array}\right]$$

$$z[n] = [12, 9, 11, 5, \underline{5}, 5, 6, 0, -4]$$

Dr. Montadar Abas Taher 2019-2020 $\boxed{8}$

EX.4 Evalute the following for the signals

$$g[n] = [\underline{2}, 0, 0, 0, 1, 2]$$

$$m[n] = [+1, 7, 0, 8, 2, \underline{4}]$$

a) $g[n] + m[n]$ b) $g[n] - m[n]$ c) Element by element multiplication of $g[n]$ and $m[n]$ or the dot product of $g[n] \cdot m[n]$

solution the two signals are not equal to each other, furthermore, the zero-point in each signal is different, we have to equlize the two signals befor any mathematical operation.

$$\begin{array}{c|ccccccccccc} & & & & & & & & & & & \\ g[n] = & 0, & 0, & 0, & 0, & 0, & \underline{2}, & 0, & 0, & 0, & 1, & 2 \\ n & -5 & -4 & -3 & -2 & -1 & 0 & 1 & 2 & 3 & 4 & 5 \end{array}$$

$$\begin{array}{c|ccccccccccc} & & & & & & & & & & & \\ m[n] = & 1, & 7, & 0, & 8, & 2, & \underline{4}, & 0, & 0, & 0, & 0, & 0 \\ n & -5 & -4 & -3 & -2 & -1 & 0 & 1 & 2 & 3 & 4 & 5 \end{array}$$

a) $g[n] + m[n] = [1, 7, 0, 8, 2, \underline{6}, 0, 0, 0, 1, 2]$

b) $g[n] - m[n] = [-1, -7, 0, -8, -2, \underline{-2}, 0, 0, 0, 1, 2]$

c) $g[n] \cdot m[n] = [0, 0, 0, 0, 0, \underline{8}, 0, 0, 0, 0, 0]$

EX.5 subtract $x[n] = \begin{cases} \left(\frac{1}{2}\right)^n & n \geq 0 \\ 0 & n < 0 \end{cases}$ from the signal $h[n] = \begin{cases} n^2 - 2 & n \geq 0 \\ 0 & n < 0 \end{cases}$

solution 1

since the two signals have the same boundries, in other words, both signals start at zero, then we only can add $\left[\left(\frac{1}{2}\right)^n - n^2 + 2\right]$

$$\therefore \; x[n] - h[n] = \begin{cases} \left(\frac{1}{2}\right)^n - n^2 + 2 & n \geq 0 \\ 0 & n < 0 \end{cases}$$

for the first few terms ; $n = 0, 1, 2$

$$x[0] - h[0] = +2 \quad , \quad x[1] - h[1] = 1.5$$

$$x[2] - h[2] = \left(\frac{1}{2}\right)^2 - 2^2 + 2 = -1.75$$

solution 2 By expanding the two signals

$$x[n] = [\underline{1}, 0.5, 0.25, 0.125, ---]$$

$$h[n] = [\underline{-2}, -1, 2, 6, -----]$$

$$\therefore \; x[n] - h[n] = [2, 1.5, -1.75, -5.875, ...]$$

Exercise #1 Find the addition of the three signals $x[n]=[-1, -\underline{2}, 3, 10, -11, 2, 41, 12]$,

$$g[n] = \begin{cases} (n)^2 & n \geq 0 \\ 0 & n < 0 \end{cases}, \text{ and } m[n]=[12, \underline{12}, 12]$$

Exercise #2 Find the dot product of $x[n]$ and $m[n]$ in exercise #1.

Exercise #3 given $H[n] = \begin{cases} 3n^2-4 & n \geq 0 \\ 0 & n<0 \end{cases}$

Find a) $x[n] = H[n]-3$.

b) $x[n] = 3H[n] - n\,H[n]$.

c) $x[n] = 2n^2-1+4H[n]$.

Exercise #4 Find $g[n] = H[-n]$ of exercise #3.

Exercise #5 Find $z[n]=H[2n]$, $x[n]=-H[2n]$, $y[n]=-nH[n]$, where $H[n]$ is given in exercise #3.