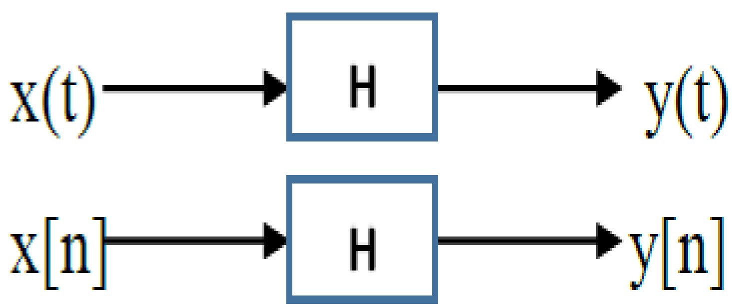
كلية الرشيد الجامعة
قسم هندسة تقنيات الحاسوب

المرحلة الثانية
مادة اسس الاتصالات
المحاضرة (9)

Systems

- A continuous-time (discrete-time) system H is an operator that transfer an input x(t) (x[n]) into output signal y (t) (y[n]).



Causal and Non-causal Systems

❖ A system is called ***causal*** if its output ***y (t)*** at an arbitrary time ***t*** depends on only the input ***x (t)*** for ***t*** **I*t o.***

❖ That is, the output of a causal system at the present time depends on only the present and/or past values of the input, not on its future values.

❖ Thus, in a causal system, it is not possible to obtain an output before an input is applied to the system. **A** system is called ***non-causal*** if it is not causal.

Examples 1

For the following check if the system is causal or non-causal

1. $Y[n] = x[n] – x[n-1]$
2. $Y[n] = ax[n]$
3. $Y[n] = x [2n]$

Answer

1. $Y[n] = x[n] - x[n-1]$

the system is causal because it depend on current and past value

2. $Y[n] = a\,x[n]$

the system is causal because it depend on current value

3. $Y[n] = x\,[2n]$

the system is non-causal because it depend on future value

Time-Invariant and Time- variant Systems

A system is called time-invariant if a time shift (delay or advance) in the input signal causes the same time shift in the output signal.

Steps of solution

Step1// find y[n , k]

That mean replace each x[n] and put x[n-k]

Step2// find y[n-k]

That mean replace each n and put n-k

Step 3

If y[n , k] = y[n-k] the system is invariant

Example 2

Check if the system is variant or invariant

$$Y[n] = x[n] - x[n-1]$$

solution

$$Y[n] = x[n] - x[n-1]$$

Step1// find y[n , k]

$$Y[n,k] = x[n-k] - x[n-k-1]$$

Step2// find y[n-k]

$$y[n-k] = x[n-k] - x[n-k-1]$$

y[n , k] = y[n-k] → the system is invariant

Example 3

Check if the system is variant or invariant

$$Y[n] = n\, x[n]$$

- **Answer**

Step1// find y[n , k]

$$Y[n , k] = n\, x[n-k]$$

Step2// find y[n-k]

$$y[n-k] = [n-k]\, x[n-k]$$

$y[n , k] \neq y[n-k]$, → the system is variant

Linear and non-linear system

A linear system is any system that obeys the properties of:

Scaling (homogeneity)

A system H has the input signal f(t) and scaling factor k then
$H(kf(t)) = kH(f(t))$

Superposition (additively)

A system **h** has the input signals x1 & x2 then the output signal must be y1+y2= x1 + x2

How to check the system is linear or not

- **step of solution**

1. Determine Y_1 , every x[n] equal to $x_1[n]$
2. Determine Y_2 , every x[n] equal to $x_2[n]$
3. Determine $Y_3 = a_1Y_1 + a_2Y_2$
4. Determine $Y4 = R[a_1x_1 + a_2x_2]$
5. If Y3 = Y4 the system is linear

Example 4

- Determine if the system $Y[n] = n X[n]$, is linear or not

Solution

Step1 **find $Y_1[n]$**

$$Y_1[n] = n X_1[n]$$

Step2 **Find $Y_2[n]$**

$$Y_2[n] = n X_2[n]$$

- **Step3** **Find Y_3**

$$Y3 = a_1 Y_1 + a_2 Y_2$$

$$Y3 = a_1\, n\, X_1[n] + a_2\, n\, X_2[n]$$

- **Step4** **Find Y_4**

$$Y[n] = n\, X[n]$$

$$Y4 = R[a_1x_1 + a_2x_2]$$

$$Y4 = n\, [a_1x_1\, [n] + a_2x_2\, [n]]$$

$$Y4 = a_1n\, x_1\, [n] + a_2n\, x_2\, [n]$$

Y4 =Y3 ➔ the system is linear

Example 5

Determine if the system Y[n] = $e^{x[n]}$ is linear or not

Solution

Step1 **find $Y_1[n]$**

$$Y_1[n] = e^{x1[n]}$$

Step2 **Find $Y_2[n]$**

$$Y_2[n] = e^{x2[n]}$$

- **Step3** **Find Y_3**

$$Y3 = a_1 Y_1 + a_2 Y_2$$

$$Y3 = a_1 e^{x1[n]} + a_2 e^{x2[n]}$$

- **Step4** **Find Y_4**

$$Y4 = R[a_1 x_1 + a_2 x_2]$$

$$Y[n] = e^{x[n]}$$

$$Y4 = e^{a1\, x1[n] + a2\, x2[n]}$$

$Y4 \neq Y3$ ➔ the system is non linear