Indian Institute of Technology, Tirupati

Digital Signal Processing Lab

Labsheet 2: LTI Systems and Convolution

Prelab:

1. Are the following statements true or false:
   (a) The cascade of two LTI systems is also LTI
   (b) The cascade of two nonlinear systems is also non-linear
2. Suppose the following three systems are connected in cascade/series, find the input-output relationship of overall system and comment whether the overall system is Linear and/or Time invariant.
   System 1: $y[n] = x[n/2]$ for n even 0 for n odd
   System 2: $y[n] = x[n] + x[n-1]/2 + x[n-2]/4$
   System 3: $y[n] = x[2n]$

Lab Exercises:

1. Obtain the convolution of the given finite sequences

$$\begin{aligned} x_1 &= \begin{bmatrix} 4 & 2_{\uparrow} & 6 & 3 & 8 & 1 & 5 \end{bmatrix} \\ x_2 &= \begin{bmatrix} 3 & 8 & 6_{\uparrow} & 9 & 6 & 7 \end{bmatrix} \end{aligned}$$

   Note: arrow points to zero location in above sequences. Since MATLAB command does not give time index of the convolved result , derive it from the signals to be convolved.
2. Find the auto correlation and cross correlation of x_1 and x_2, with the help of convolution.
3. `exp(x)` is the exponential of the elements of x (i.e., e^x). For complex number z=x+iy, `exp(z) = exp(x)*(cos(y)+i*sin(y))`. Taking appropriate values for z,
   (a) generate and plot a complex-valued exponentially decaying sinusoidal sequence.
   (b) generate and plot a complex-valued exponentially growing sinusoidal sequence using MATLAB.
4. Find solution for y[n] from difference equation $y[n] = ay[n-1]+x[n]$, with $x[n] = \delta[n]$ and simulate it using "filter" command. Can you relate it to any of the standard signals?
5. Generate complex exponential signal as impulse response to the following difference equation:

$$y[n] = z_0 y[n-1] + x[n], \text{where, } z_0 = 0.8e^{j\frac{\pi}{3}}. \quad (1)$$

6. Use "filter" function to generate and plot the impulse response h[n] of the following difference equation. Plot h[n] in the range $-10 <= n <= 100$

$$y[n] - 1.8cos(\frac{\pi}{16})y[n-1] + 0.81y[n-2] = x[n] + 0.5x[n-1]$$