SS Lab # 8

OBJECTIVES OF THE LAB

This lab aims at the understanding of:

- *Making Signals Causal and Non-Causal*
- *Convolution*
- *Properties of Convolution*

8.1 MAKING SIGNALS CAUSAL AND NON-CAUSAL

Causal Signals: A signal is said to be causal if it is zero for time t<0. A signal can be made causal by multiplying it with unit step. This is shown in example below and graphically in Figure 8.1.

Example

```
clc
clear all
close all

t= -2:1/1000:2;
x1 = sin(2*pi*2*t);

subplot(3,1,1);
plot(t,x1,'LineWidth',2);
xlabel('time');
ylabel('signal amplitude');
title('sin(2*\pi*f*t)');

u = (t>=0);
x2 = x1.*u;

subplot(3,1,2);
plot(t,u, 'r','LineWidth',2);
xlabel('time');
ylabel('Signal Amplitude');
title('Unit Step');

subplot(3,1,3);
plot(t,x2, 'k','LineWidth',2);
xlabel('time');
ylabel('signal amplitude');
title('causal version of sin(2*\pi*f*t)');

figure;
plot(t,x1,t,u,'-.',t,x2,'LineWidth',2);
text(0,1.2,'u(t)','FontSize',16);
text(-1.2,-1.1,'x(t)','FontSize',16);
text(0.8,-1.1,'x(t)*u(t)','FontSize',16);
axis([-2 2 -1.5 1.5]);
```

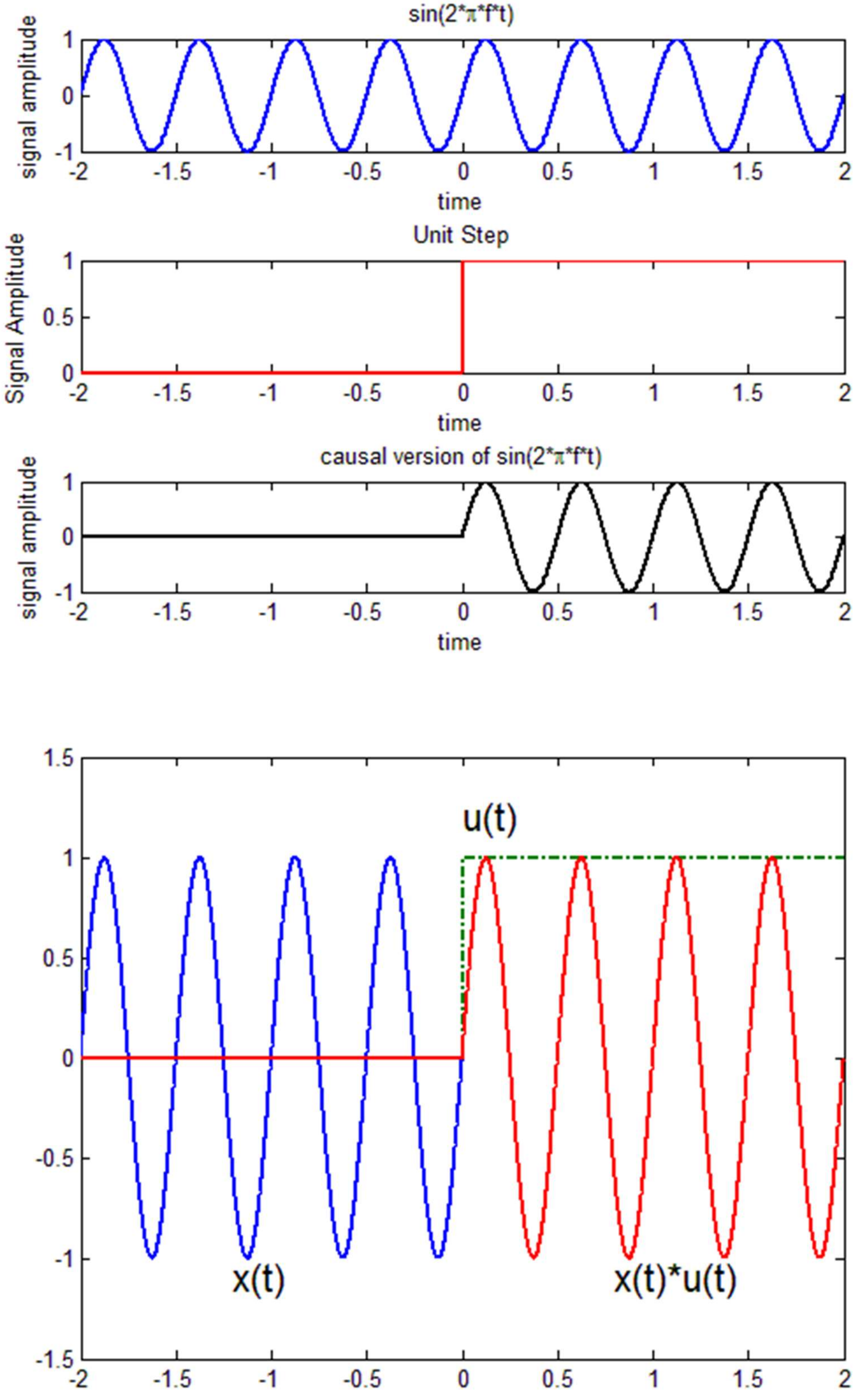


Figure 8.1 – Causal Signal Generation in Matlab

---------------------------TASK 01-------------------------

Sample the signal given in above example to get its discrete-time counterpart (take 10 samples/sec as sampling rate). Make the resultant signal causal. Display the lollipop plot of each signal.

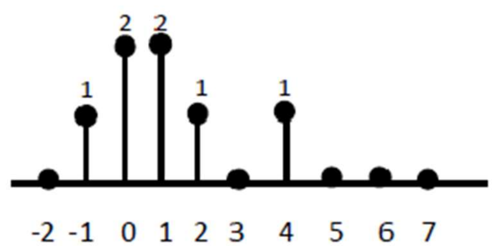
---------------------------TASK 02-------------------------

A signal is said to be anti-causal if it exists for values of n<0. Make the signal given in above example anti-causal.

---------------------------TASK 03-------------------------

Create a function by name of **sig_causal** in Matlab that has two input arguments: (i) a discrete-time signal, and (ii) a position vector. The function should make the given signal causal and return the resultant signal to the calling program.

A non-causal signal is shown in the Fig below. Write Matlab code to make the signal causal by callingthe above-mentioned function. Plot the original non-causal signal and the resultant causal signal.



8.2 CONVOLUTION

Use the Matlab command conv(h, x) to find convolution where

h – impulse response

x – input signal

Example

```
clc
clear all
close all

h = [1 2 3 4 5 4 3 2 1];
x = sin(0.2*pi*[0:20]);
```

```
y = conv(h, x);

figure(1);
stem(x);
title('Discrete Filter Input x[n]');
xlabel('index, n');
ylabel('Value, x[n]');

figure(2);
stem(y, 'r');
title('Discrete Filter Output y[n]');
xlabel('index, n');
ylabel('Value, y[n]');
```

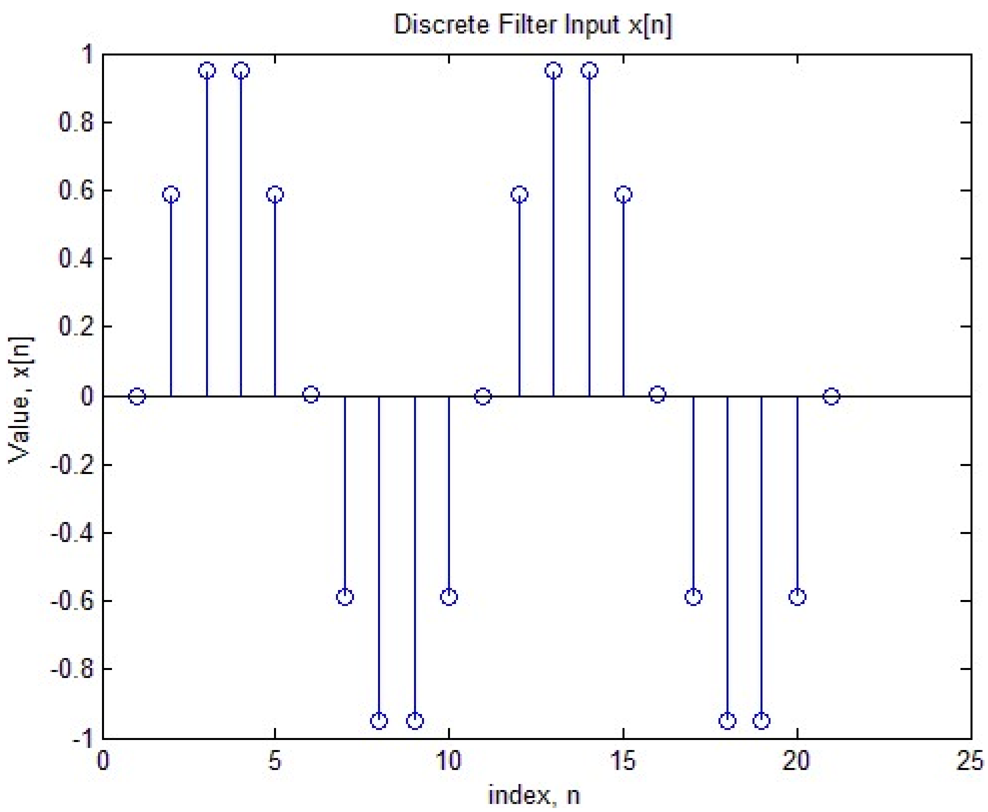


Figure 8.2 – Input Discrete-Time Signal

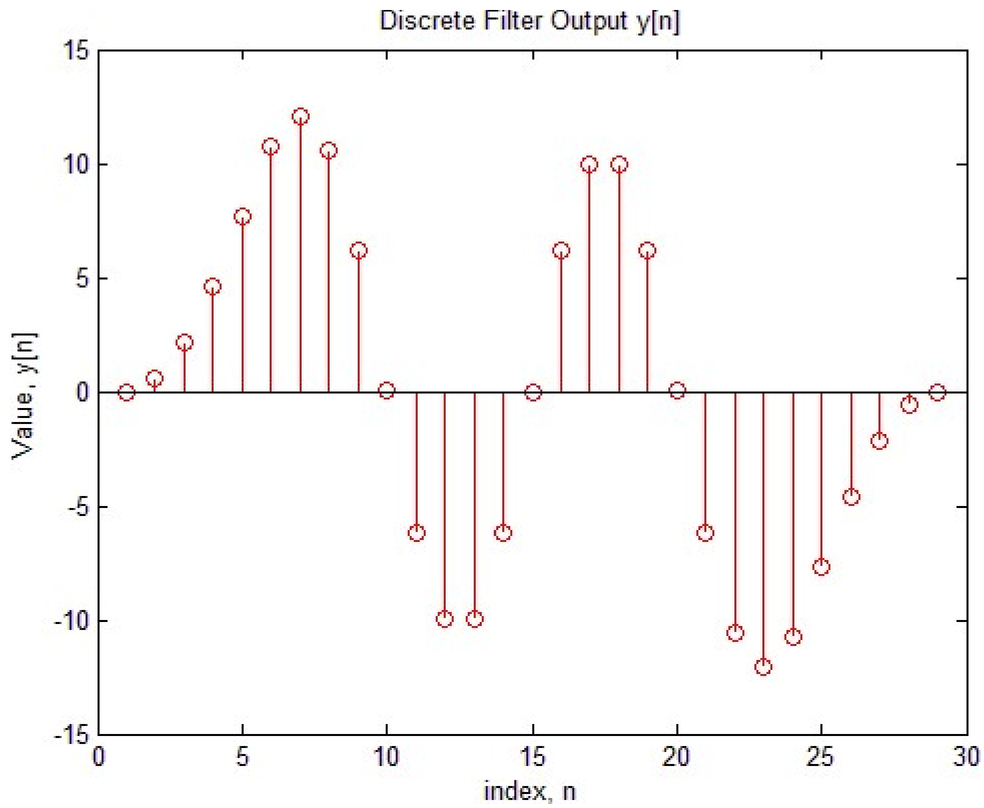


Figure 8.3 – Output Discrete-Time Signal from the Given System

Even though there are only 21 points in the x array as shown in Figure 8.2, the conv function produces 8 more points because it uses the convolution summation and assumes that x[n] = 0 when n>20. This is shown in Figure 8.3.

----------------------------TASK 04--------------------------

Convolve the following signals:

x =[2 4 6 4 2];

h =[3 -1 2 1];

Plot the input signal as well as the output signal.

----------------------------TASK 05--------------------------

Convolve the signal x[n]=[1 2 3 4 5 6] with an impulse delayed by two samples. Plot the original signal and the result of convolution.

--------------------------TASK 06-------------------------

Convolution is associative. Given the three signal $x_1[n]$, $x_2[n]$, and $x_3[n]$ as:

$x_1[n]= [3\ 1\ 1]$

$x_2[n]= [4\ 2\ 1]$

$x_3[n]=[3\ 2\ 1\ 2\ 3]$

Show that $(x_1[n] * x_2[n]) * x_3[n] = x_1[n] * (x_2[n] * x_3[n])$.

--------------------------TASK 07-------------------------

Convolution is commutative. Given x[n] and h[n] as:

X[n]=[1 3 2 1]

H[n]=[1 1 2]

Show that $x[n] * h[n] = h[n] * x[n]$.

--------------------------TASK 08-------------------------

Determine h[n] for the system:

$$y[n] = \sum_{k=0}^{10} kx[n - k]$$

When $x[n] = 2\delta[n]$. Plot the input signal, impulse response, and output signal.

--------------------------TASK 09-------------------------

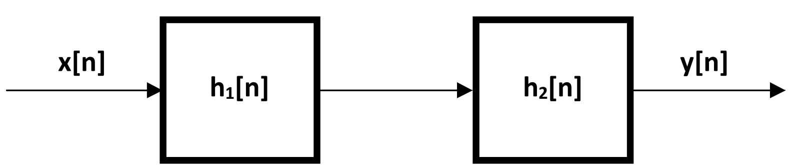
Given the impulse response of the systems as:

$$h[n]= 2\delta[n] + \delta[n-1]+ 2\delta[n-2]+ 4\delta[n-3]+ 3\delta[n-4]$$

If the input $x[n] = \delta[n]+ 4\delta[n-1] +3\delta[n-2] + 2\delta[n-3]$ is applied to the system, determine the output ofthe system.

--------------------------TASK 10-------------------------

Two systems are connected in cascade.



$h_1[n]=[1\ 3\ 2\ 1]$

$h_2[n]=[1\ 1\ 2]$

If the input $x[n] = \delta[n]+ 4\delta[n-1] +3\delta[n-2] +2\delta[n-3]$ is applied, determine the output.

--------------------------TASK 11-------------------------

Given the signals:

$x_1[n]= 2\delta[n] -3\delta[n-1]+ 3\delta[n-2] +4\delta[n-3] -2\delta[n-4]$

$x_2[n]= 4\delta[n]+ 2\delta[n-1]+ 3\delta[n-2] - \delta[n-3] -2\delta[n-4]$

$x_3[n]= 3\delta[n]+ 5\delta[n-1]-3\delta[n-2] +4 \delta[n-3]$

Verify that

$x_1[n] * (x_2[n] * x_3[n]) = (x_1[n] * x_2[n]) * x_3[n]$

$x_1[n] * x_2[n]= x_2[n] * x_1[n]$